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Final

## Site Inspection Sampling and Analysis Plan

### Bennett Army National Guard Facility Bennett, Colorado

Prepared for:

U.S. ARMY ENVIRONMENTAL CENTER  
ABERDEEN PROVING GROUND, MARYLAND 21010-5401

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January 1995

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# SITE INSPECTION SAMPLING AND ANALYSIS PLAN

BENNETT ARMY NATIONAL GUARD FACILITY  
BENNETT, COLORADO

FINAL

USAEC CONTRACT NO. DAAA15-14-D-0013

TASK ORDER 0001

Prepared for:

U.S. Army Environmental Center  
Aberdeen Proving Ground, Maryland 21010-5401

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January 25, 1995

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## LIST OF ACRONYMS AND ABBREVIATIONS

ARARs	Applicable or Relevant and Appropriate Requirements
BANGF	Bennett Army National Guard Facility
bgs	Below Ground Surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	Chain-of-Custody
CRZ	Contamination Reduction Zone
EA	Environmental Assessment
FONSI	Finding of No Significant Impact
FS	Feasibility Study
IDW	Investigation-Derived Waste
LOX	Liquid Oxygen
NEPA	National Environmental Policy Act
NTP	Notice to Proceed
OD	Outside Diameter
OVA	Organic Vapor Analyzer
PA	Preliminary Assessment
PCBs	Polychlorinated Byphenyls
PID	Photoionization Detector
ppm	Parts per Million
PVC	Polyvinyl Chloride
QC	Quality Control
RI	Remedial Investigation
SI	Site Inspection
SVOCs	Semivolatile Organic Compounds
TAL	Target Analyte List
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure

## **LIST OF ACRONYMS AND ABBREVIATIONS**

**(continued)**

TPH	Total Petroleum Hydrocarbons
USAEC	U.S. Army Environmental Center
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
VOA	Volatile Organic Analyses
VOCs	Volatile Organic Compounds

## **1.0 INTRODUCTION**

In December 1988, the Defense Secretary's Commission on Base Realignment and Closure released a report which recommended the Bennett Army National Guard Facility (BANGF) for closure. In March 1989, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), since renamed the U.S. Army Environmental Center (USAEC), was assigned the responsibility for centrally managing the Base Realignment and Closure Environmental Restoration Program. As part of this program, sample design plans were prepared by R.L. Stollar & Associates (1991) to support the performance of a Remedial Investigation and Feasibility Study (RI/FS) at BANGF. Subsequent to the initial preparation of the plans, funding was suspended, and the actual RI/FS field work was not conducted. In September 1993, BANGF was selected for inclusion on the Federal Agency Hazardous Waste Compliance Docket. EPA policy requires a preliminary assessment (PA) and, if warranted, a site inspection (SI) be submitted within 18 months of being listed on the docket. This Sampling and Analysis Plan has been prepared to support an SI to meet this requirement.

This Sampling and Analysis Plan is based on the RI/FS sample design plan originally developed by R.L. Stollar & Associates in 1991. This SI Sampling and Analysis Plan has been modified based on the scope of work for a SI of this facility. This document presents the sampling objectives, site history, specifications of equipment, analyses of interest, sample types, and sample locations for the SI. This document and the site specific Health and Safety Plan have been prepared to serve as a field manual during the data collection program.

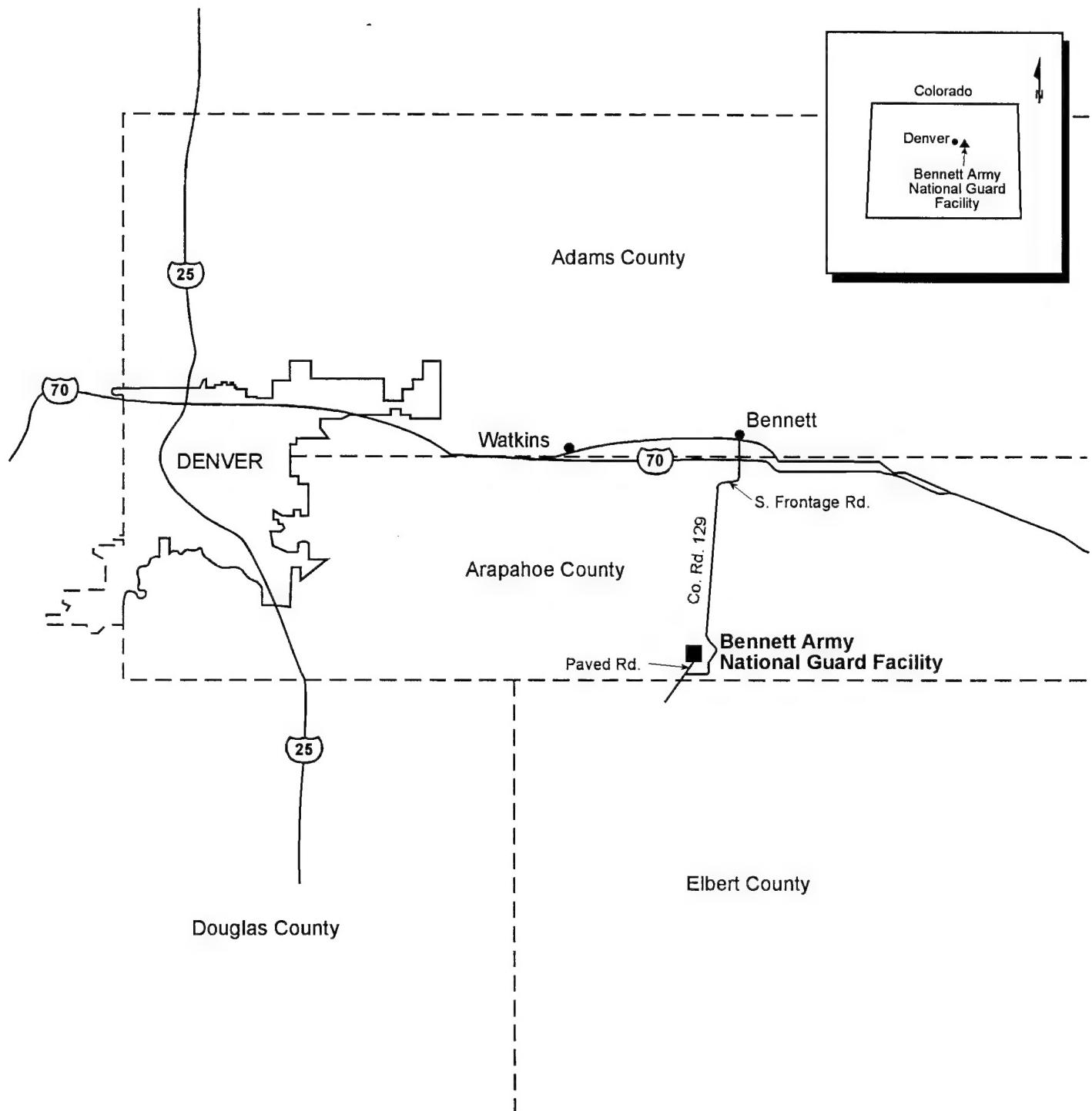
### **1.1 PURPOSE AND SCOPE**

A portion of the BANGF was formerly used as a Titan I missile complex. The BANGF is located approximately 10 miles south of Bennett in Arapahoe County, Colorado (Figure 1-1). Roy F. Weston, Inc. completed a PA of the BANGF in January 1990. This PA identified potential contaminant source areas on the surface of the site and inside the underground structure. The SI will be performed to obtain and analyze environmental samples, investigate human and environmental exposure to hazardous substances, and test PA hypotheses that are the basis of the further action conclusion.

### **1.2 SITE INSPECTION OBJECTIVES**

The objectives of the SI at the BANGF are:

- Conduct sampling at the potential contaminant source areas previously identified during the PA.
- Perform chemical analysis of soil, groundwater, and standing water samples.



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#### SITE LOCATION MAP

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FIGURE 1-1

- Perform data validation.
- Prepare a SI report that details the analytical results and compares the groundwater and standing water results with applicable or relevant and appropriate requirements (ARARs). Soil sample results will be compared to background concentrations and state standards, where applicable.

### **1.3 SITE HISTORY**

The BANGF was part of the Lowry Air Force Bombing Range from 1941 to 1958. In 1959, construction of a Titan I Intercontinental Ballistic Missile complex began. The missile complex was initially known as Complex 2-A, and is located approximately in the center of the current 242 acre BANGF site. The complex was operational from October 1961 to May 1965 when the missiles were removed and the facility was closed. The equipment which remained in the facility was salvaged in 1971, and subsequently, the property was reported as excess. In 1975, the Colorado Army National Guard leased the surface of the property for tactical aviation training, and ownership of the property was transferred from the General Services Administration to the Department of the Army in 1978.

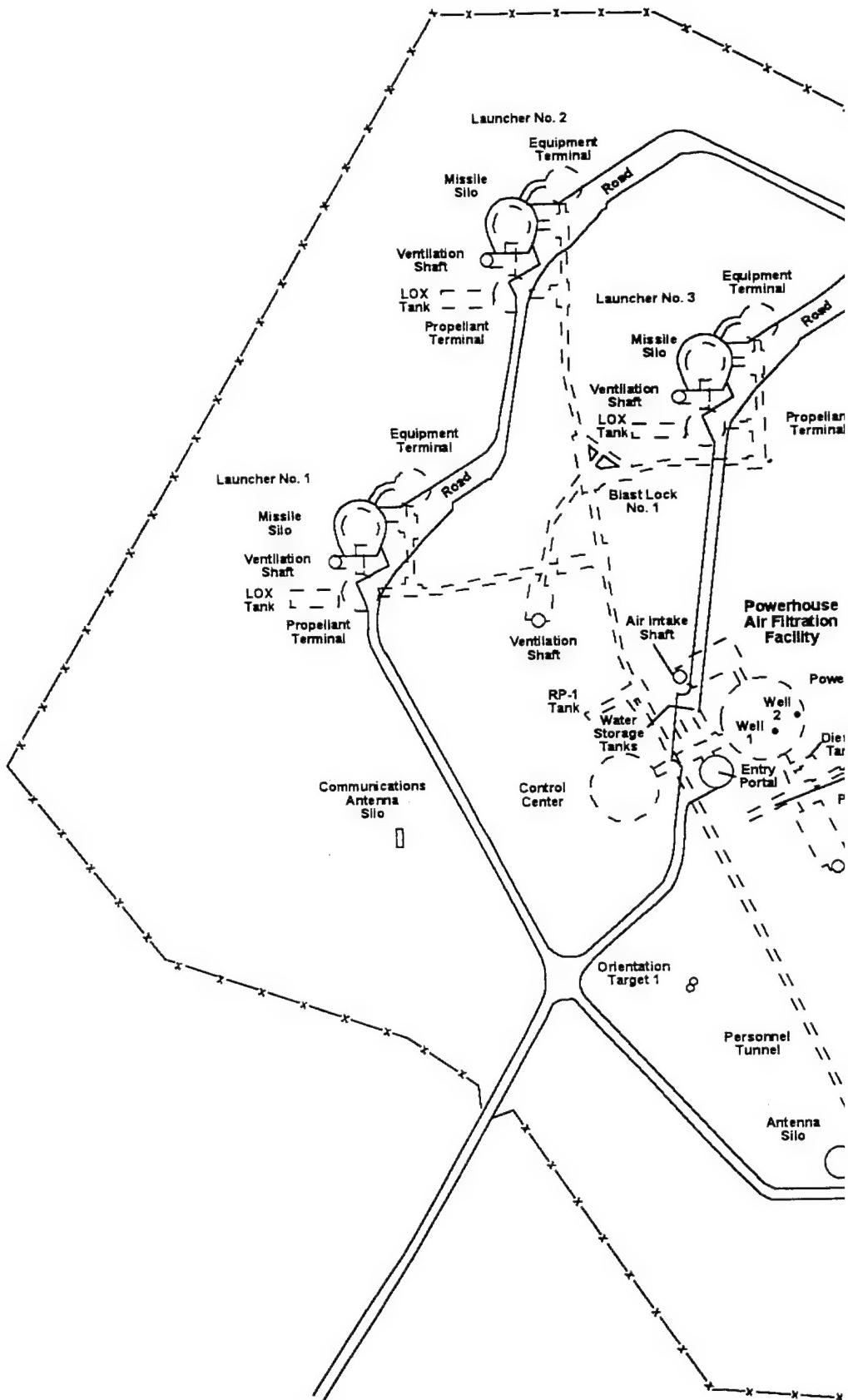
### **1.4 DESCRIPTION OF FACILITY**

According to Roy F. Weston, Inc. (1990), the missile complex contains three missile launch complexes, a powerhouse, a control center, an antenna terminal and utility systems which allowed the facility to operate self-sufficiently (Figure 1-2). Approximately 2,100 feet of tunnels connect these components of the complex. The tunnels, constructed of 9.5-ft diameter corrugated metal sections, allowed personnel access and carried utility piping.

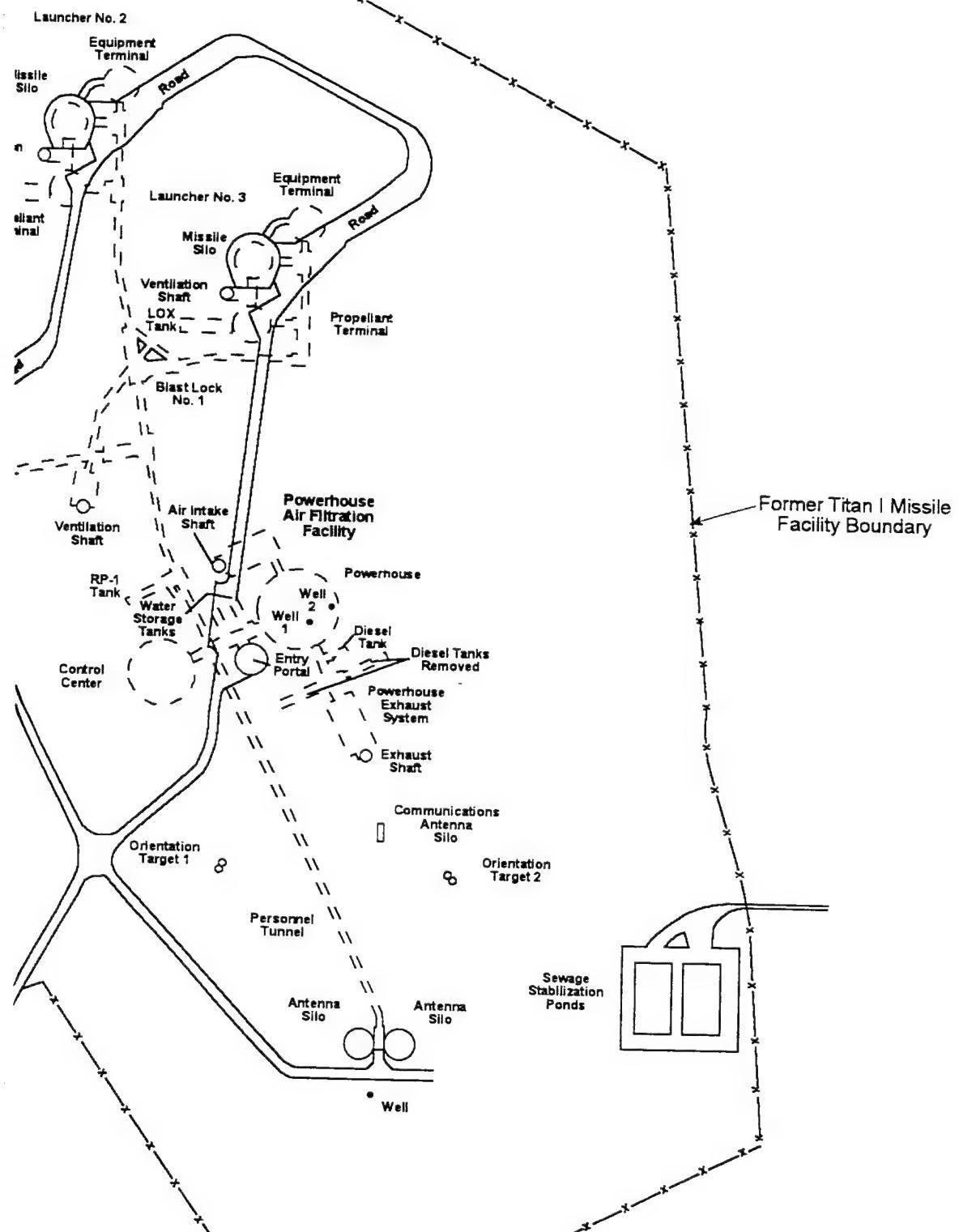
#### **Powerhouse**

The powerhouse provided electric power, heat, air conditioning, and water for the facility. This dome-shaped structure, with walls from 12 inches to 30 inches thick, is 120 ft in diameter at its base and 46 ft high. To strengthen the concrete structure, over 190 miles of prestressed wire were wrapped around the base of the powerhouse.

Four large diesel generators, each capable of producing approximately 1,000 kilowatts of electric power, were located on the first level. The powerhouse had two large air-conditioning units, each with a 250-ton capacity to provide the necessary air to cool these generators. Three supplemental ice banks were installed on the first floor as a backup for this equipment, with each bank holding 30,000 lbs of ice. The resulting cool air was used to reduce the temperature within the powerhouse and in the guidance equipment in the launch control center. Heat produced by the generators was used to provide hot water throughout the complex and to heat various facilities. Also included on this first level were the water filtration equipment and water and fuel pumps.

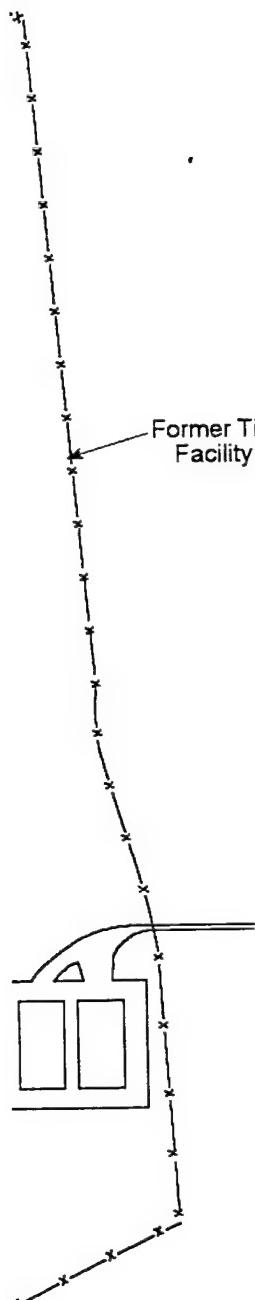


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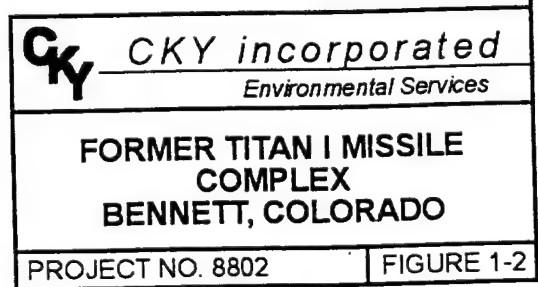


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The domestic water facilities consisted of demineralizers, chlorinators, tanks, and pumps. Located beneath the powerhouse are two wells, each about 1,800 ft deep. These wells provided water for the entire complex.

Adjacent to the powerhouse were a number of storage tanks. These included two diesel fuel tanks, each with a capacity of 67,000 gallons for operating the generators, and water storage tanks with a total capacity of 60,000 gallons. There was also one 5,000-gallon diesel fuel tank, called the "start tank," that provided the fuel to start the generators.

### Control Center

The launch control center was the command center of the entire missile complex. It is a two-level, dome-shaped structure, slightly smaller than the powerhouse. The inside diameter is 105 ft at the first floor level and 85 ft at the upper level. The lower level housed the living and working areas and was divided into ready rooms, dining hall and kitchen, air conditioning and electrical equipment rooms, and an equipment maintenance ready room. The top level contained various consoles, time display and status boards, and electronic and communications equipment. This equipment controlled and monitored the operations within the complex and was capable of giving an immediate visual status of the weapon system's state of readiness.

Associated with the control center, yet separated from the rest of the complex, are two antenna silos 27 ft in diameter and 71 ft high. The equipment in each silo was identical, with one used as backup for the other in the event one was destroyed or rendered inoperative.

### Launch Areas

The Titan installation is equipped with three identical launch areas. Each launch complex contains a propellant terminal, an equipment terminal, and a missile silo. The propellant terminal is a two-level, silo-type structure 47 ft high and 40 ft in diameter. Liquid nitrogen and helium were stored here to provide the pressure to load the fuel and liquid oxygen (LOX) aboard the missiles. Also located within this terminal were the LOX and helium subcoolers and the LOX sump. The LOX subcooler was a tank through which the liquid oxygen passed and was cooled by liquid nitrogen prior to being loaded into the missiles. Helium was pumped into the LOX tanks to provide the necessary pressure to prevent fuel sloshing in the tanks.

The first level of the propellant terminal contained the LOX sump pumps and a drainage facility for the liquid oxygen overflow. In addition, there were nine clusters of nitrogen and helium tanks that extended upwards into the second level and one 3,500-gallon tank that contained sulfuric acid.

The equipment terminal is a silo-shaped structure located next to the missile silo. This structure stored much of the equipment used to prepare and launch the missiles. It consists of four levels and is 62 ft high and 43 ft in diameter. The first level was called

the powerpack room and contained the launcher logic racks, which provided automatic checkout of the launcher equipment and the hydraulic equipment used to raise and lower the missile launch platform. The second level contained the air conditioning unit which maintained proper temperature and humidity in the silo. The third level distributed electric power for the ground operating equipment, missile electrical system, ground hydraulic power unit, and the missile air conditioning system. Also located on this third level were the fuel loading and unloading equipment. On the fourth level, the power produced by the four diesel generators in the powerhouse was stepped down from 2,400 volts to 480 volts.

The missile silo measures 163 ft from ground level to the base of the foundation and has an inside diameter of 40 feet. The foundation is 8 ft thick; the walls vary in thickness from 2 ft to 11 feet. On top of the missile silo are two 116-ton doors that were raised and lowered hydraulically.

During operation of the Titan complex, sanitary wastewater was discharged into two sewage stabilization ponds located in the southeastern corner of the property. The treated effluent was conveyed by a drainage ditch that discharged to an intermittent stream which led to Kiowa Creek.

Liquids, including groundwater and surface water, which collected in sumps throughout the complex, were pumped to the surface, treated with calcium carbonate and released into intermittent drainages discharging into Kiowa Creek. The liquids were treated in two different types of units, which employed the similar processes, known as chemical waste clarifier and the seal chambers.

The fuel terminal, which contains a 40,000-gallon propellant tank and several nitrogen tanks, is located approximately 100 ft north of the control center. An alcohol/kerosene based propellant was stored in this terminal and nitrogen was used to transfer the propellant.

## **1.5 PREVIOUS INVESTIGATIONS**

During 1989 and 1990, a PA (Weston, 1990) of the site, an Environmental Assessment (EA) (USACE, 1990) pursuant to the National Environmental Policy Act, and an inspection of the underground complex (Stollar & Associates, et al., 1991) were conducted. The PA was conducted to evaluate whether environmental contamination is potentially present at the site. The EA was prepared concurrently with the PA. This report, prepared for the U.S. Army National Guard Bureau, characterized the impacts of the closure of the facility. The inspection of the underground complex was completed in order to document the conditions of the facility and determine whether any hazardous materials were present. Results of these investigations are summarized below and have been utilized in the development of the SI sampling program for the facility.

### Preliminary Assessment

An enhanced PA of the facility was performed to identify and characterize "environmentally significant operations" which have been conducted at the BANGF (Weston, 1991). The PA characterized potential risks associated with these operations and identified them as study areas for future investigations.

These study areas were identified by a review of available historical information, a visual inspection of the surface of the facility, and interviews with personnel associated with the facility. The study areas which were identified include wastewater discharges from the complex, potential waste disposal locations, possible polychlorinated biphenyl (PCB) containing transformers mounted on a power pole, and discarded asbestos insulation inside the complex.

### Environmental Assessment

An EA and Finding of No Significant Impact (FONSI) was conducted by the U.S. Army Corps of Engineers in May 1990. The purpose of the EA was to evaluate the potential impacts of the closure of the BANGF. The study was prepared in accordance with Army Regulation 200-2 for the purpose of compliance with the National Environmental Policy Act (NEPA). The EA concludes that the closure action will have minor effects on current or potential land uses. The study states that no threatened or endangered animal or plant species have been found at the site and that due to the extensive disturbance during construction, no cultural resources are expected to be present at the site. Possible future land uses for the BANGF which are considered in the study include extension of the rural residential development, storage of grain or records inside the complex, agriculture, and grazing.

### Facility Inspection

During the development of the original RI/FS work plan package, Stollar & Associates (1991) conducted an inspection of the missile complex in 1990 to evaluate whether any hazardous materials were present and to document and videotape the condition of the facility. The videotape of this inspection was reviewed by CKY to aid in the development of the SI work plan package. Detailed results of the inspection are provided in Appendix A. Most of the equipment has been removed from the complex; discarded piping, insulating materials, scrap metal, and a few storage tanks remained. Several samples of the friable insulation were collected and laboratory results indicate that they contained 50 to 75 percent asbestos (Appendix B). A diesel tank, a propellant tank, and several unidentified tanks were observed in the complex. The propellant tank contained RP-1, an alcohol-kerosene based fuel. The diesel tank, which has a capacity of 5,000 gallons, was open and contained approximately 2 inches of liquid. The other tanks were sealed and product levels could not be identified. Water was present in the launch complex silos, the antenna silos, the tunnel junction rooms, and piping trenches throughout the facility. The source and quality of this water are unknown.

## **2.0 ENVIRONMENTAL SETTING**

The BANGF is located approximately 10 miles south of Bennett in Arapahoe County, Colorado. The property covers an area of approximately 242 acres with an additional 106 acres of easement land (USACE, 1990). The site is located on rolling terrain in a rural area, surrounded by a sparsely populated residential subdivision called the Denver East Ranchette. The Arapahoe County Planning Commission reports that the area is not expected to undergo rapid residential or commercial development (Weston, 1990).

### **2.1 CLIMATE**

The BANGF is located in a semi-arid environment and, according to data collected at Stapleton Airport which is approximately 18 miles west of the site, receives approximately 15 inches of precipitation annually. The majority of precipitation falls in the spring and summer months, and May is the wettest month with an average precipitation of 2.47 inches. January is the driest month with normal precipitation of 0.51 inches. Temperatures vary moderately from season to season. Average monthly temperatures range from 29.5°F in January to 88°F in July. Wind data collected at Stapleton Airport indicate that the prevailing wind direction is from the south, with a secondary maximum of south-southeasterly winds.

### **2.2 GEOLOGY AND HYDROGEOLOGY**

The BANGF is located within the Denver Basin, a broad structural depression encompassing northeastern Colorado and portions of southeastern Wyoming and southwest Nebraska. The Denver Basin is a north-south trending asymmetric syncline with a gently dipping eastern flank and a steeply dipping western flank which borders the front range of the Rocky Mountains. The site lies on the eastern flank of the basin.

The Denver Basin was downwarped during the Late Cretaceous and early Tertiary periods. Sediments deposited during this time comprise the Fox Hills Sandstone, Laramie Formation, Arapahoe Formation and the Denver Formation. These strata, which overlie approximately 7,000 ft of Cretaceous Pierre Shale, yield usable quantities of potable water (Robson, 1987).

Residential wells in the vicinity of the site obtain water from the Denver aquifer, which is approximately 600 ft thick in this area. The Denver aquifer consists of a series of interbedded shale, claystone, siltstone and sandstone in which coal and fossilized plant remains are common. Distinguishing characteristics of the unit are its olive, green-gray, brown and tan colors; the presence of coal, and the preponderance of shale and claystone compared to other rock types. The predominant olive and green-gray colors in the formation are due to the presence of iron-rich sediments derived from erosion of basaltic and andesitic lavas. Water-bearing layers of sandstone and siltstone occur in poorly defined, irregular beds that are dispersed within relatively thick sequences of claystone and shale. Individual sandstone and siltstone layers are commonly lens

shaped and range from a few inches to as much as 50 ft in thickness (Robson, 1987). Coal and lignite beds also form water-bearing layers where fractured.

In the vicinity of the BANGF, The Denver Formation is capped by a thin layer of alluvial and eolian sediments. Well logs record alternating layers of sandstone and shale, and a coal seam has been reported at approximately 60 ft below ground surface. This coal was present at the intended location of footings for the powerhouse (USACE, 1961) and was removed and replaced with sand fill to provide better structural support for the facility.

Within the Denver aquifer, water moves laterally through the permeable sandstone and coal strata from areas of recharge toward areas of discharge. On a local scale, water moves from the highland recharge areas in the outcrop through the upper part of the aquifer, or through perched aquifers, to the discharge areas in nearby stream valleys. In these stream valleys, water from the bedrock discharges into streams, alluvial aquifers along the stream channels, or is consumed by vegetation. Regional potentiometric surface maps (Robson, 1987) and records of nearby wells show that the water table at BANGF is at least 100 ft below ground surface (bgs).

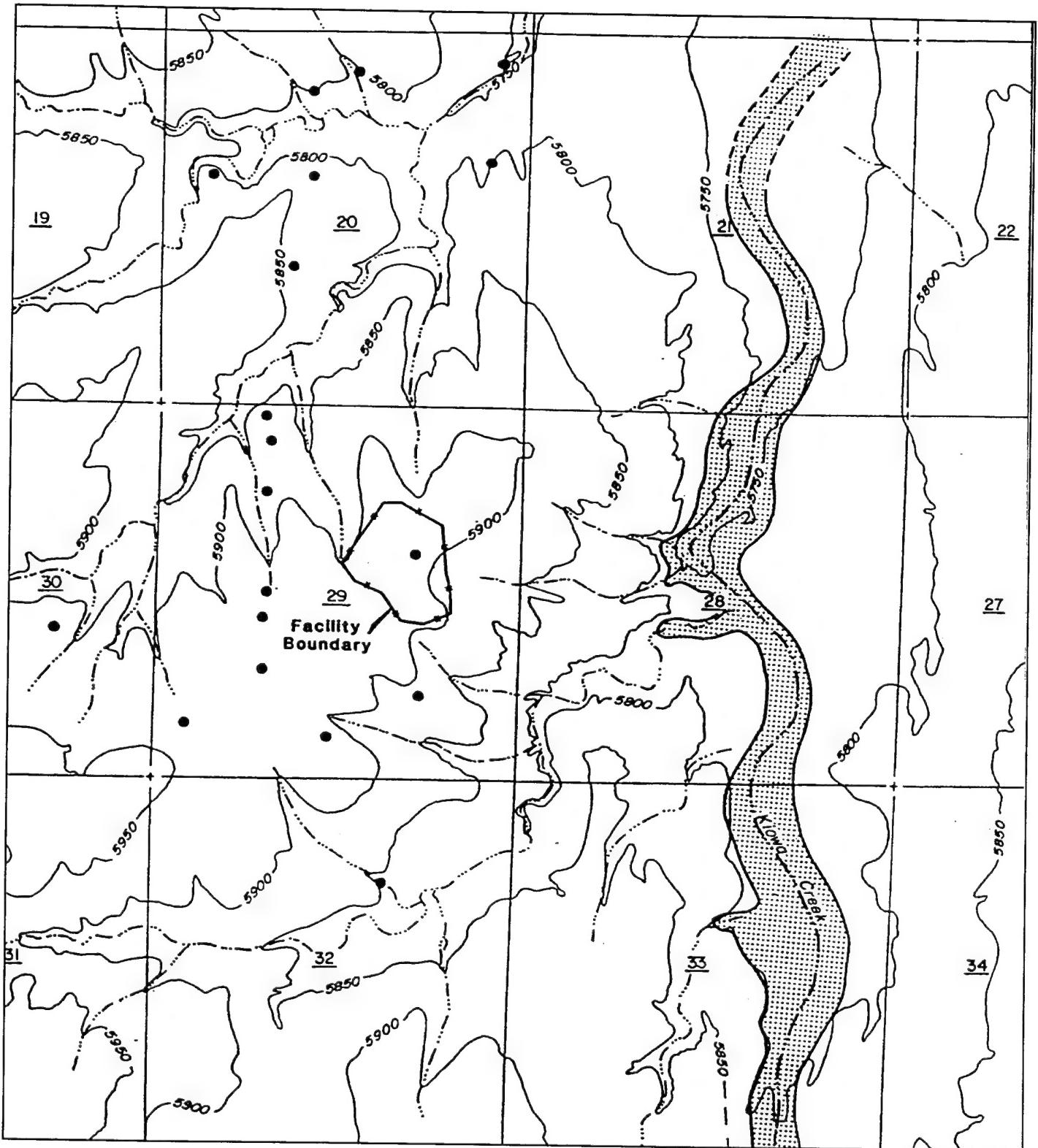
The hydrogeology of the site may be influenced by construction activities for the Titan complex. A large area was excavated to a depth of 45 to 60 ft bgs for installation of the underground facilities. The area was backfilled with the excavated material following the construction. Surface water runoff may percolate through this fill material, which is expected to be more permeable than the surrounding Denver Formation, and be retained at the interface with the undisturbed Denver Formation. Water which is held in the fill material may then move into waterbearing sandstone or coal layers in the Denver Formation.

## 2.3 SURFACE WATER

The site lies in the Kiowa Creek subdrainage of the South Platte River drainage basin. Surface water drains to the north and east from the site toward Kiowa Creek. Kiowa Creek is a intermittent tributary of the South Platte River located approximately one-half mile east of the site. The Federal Emergency Management Agency (1989) has classified the site as Zone X, which signifies that it lies outside of the 100-year flood plain (Figure 2-1).

## 2.4 SOILS

Figure 2-2 illustrates the soil classifications for the BANGF and the surrounding area (USDA, 1971). The soil on the BANGF is classified as Colby silt loam. The Colby Series consists of deep, well drained, gently sloping to steep soils that occur on ridgetops. These soils have a moderate rate of water intake, moderate permeability and high water holding capacity. They are moderate in natural fertility but are highly susceptible to wind and water erosion. The soils on the BANGF property have been extensively disturbed by the construction of the underground complex and subsequent activity and may not be accurately represented by the description of the Colby soils.



#### Explanation

- Permitted Groundwater Supply Well



100 Year Flood Plain



Drainage

Source: Stollar, 1991



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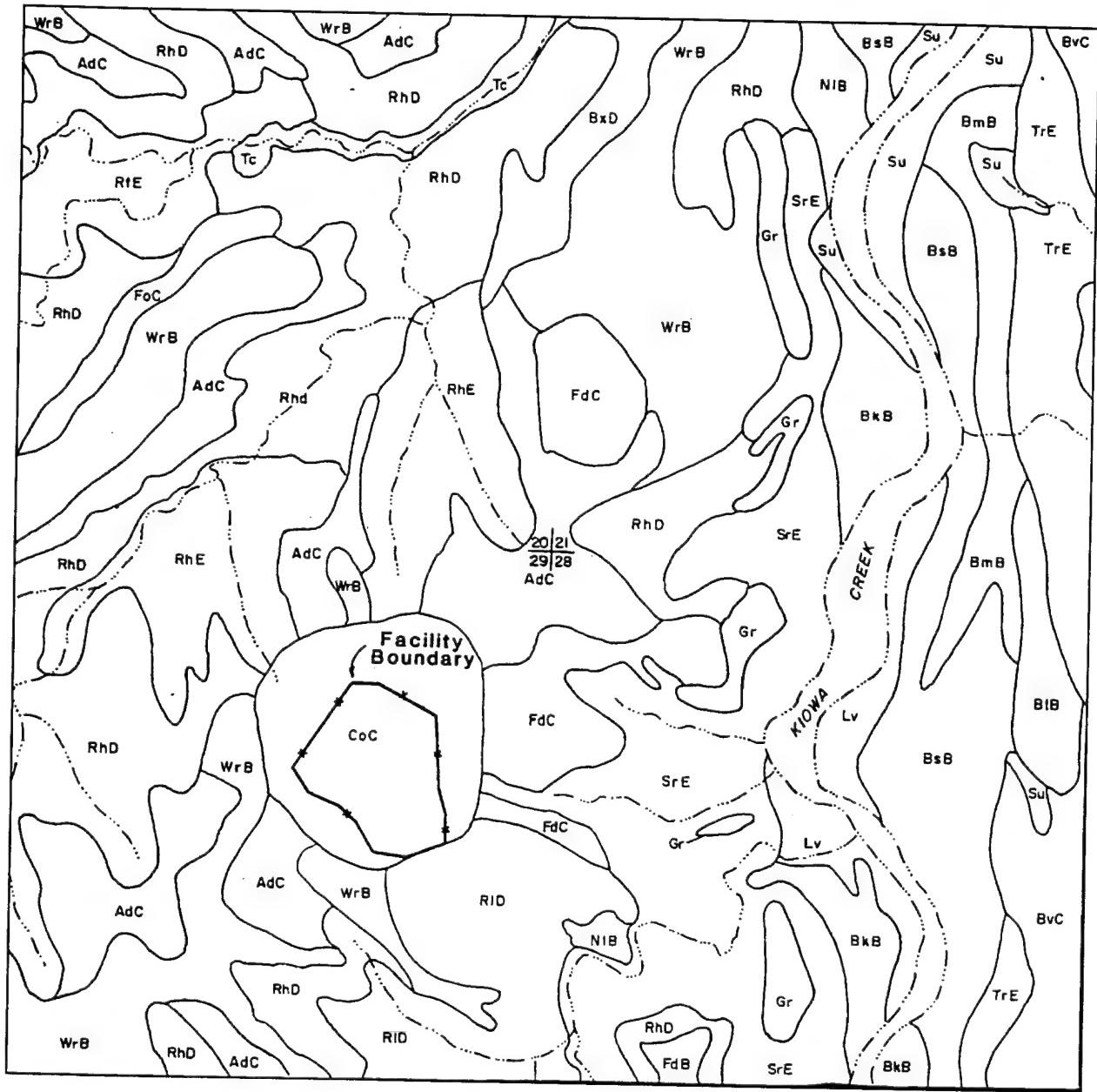
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TOPOGRAPHIC MAP

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FIGURE 2-1

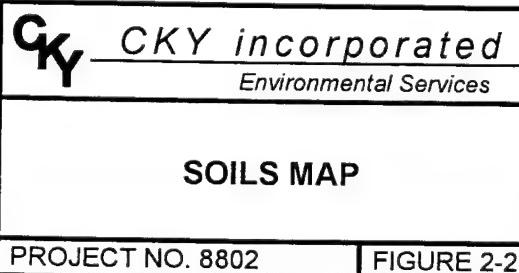


Source: Stollar, 1991

Scale in Feet  
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#### Explanation

AdC	Adena Colby silt loam	RtE	Renohill-Little-Thedalund complex
BkB	Beckton loam	SrE	Samsil-Renohill clay loam
BIB	Bijou sandy loam	Su	Sandy alluvial land
BmB	Bijou sandy loam, wet	TrE	Truckton loamy sand
BsB	Bresser sandy loam	Tc	Terrace Escarpments
BxD	Buick loam	WrB	Weld-Deertail silt loam
CoC	Colby silt loam		
FdB	Fondis silt loam (1 to 3 percent slopes)		
FdC	Fondis silt loam (3 to 5 percent slopes)		
FoC	Fondis-Colby silt loams		
Gr	Gravelly land		
Lv	Loamy alluvial land		
NIB	Nunn loam		
RhD	Renohill-Buick loam (3 to 9 percent slopes)		
RhE	Renohill-Buick loam (9 to 20 percent slopes)		



Soils in the area surrounding the site include the Renohill-Buick loams which generally lie on drainage slopes north and east of the site; the Samsil-Renohill clay loam, the Weld-Deertrail silt loam and the Fondis silt loam which occur on upland areas; and the Adena Colby silt loam which is present in areas of undulating terrain. The Renohill-Buick loams are characterized by medium to rapid surface-water runoff and moderately slow water intake ability. The upland soils generally have moderate permeability, high water-holding capacity and high natural fertility; however, they are extremely susceptible to erosion. The Samsil-Renohill clay loam has very slow water intake capacity and moderate to rapid surface-water runoff.

## **2.5 BIOTA**

The native vegetation at the site is characterized as short grass prairie and includes such typical species as western wheatgrass and blue grama. Prickly-pear cactus, which is native to the area, is present on the site and a cottonwood is growing at the corner of a building foundation. No threatened or endangered plant species listed by the State of Colorado have been identified at the site (Weston, 1990).

## **2.6 STUDY AREA**

Potential contaminant sources that were previously identified during the PA of the BANGF are contained within the property boundaries. Therefore, the property boundary will serve as the boundary of the investigation for the SI. Off-site information, such as water levels in surrounding residential wells, may be used to augment information collected during the SI. If contaminants are determined to be present at the facility and migrating beyond the property boundary, further action may be required to investigate the full extent of potential contamination.

## **3.0 SAMPLING PROGRAM**

The sampling program for the SI includes the collection of soil samples from the surface of the site and borings; groundwater samples from monitoring wells; residual samples from tanks remaining underground; and standing water samples from the underground complex. Field samples will be collected for chemical analysis; soil samples from borings will also be used for lithologic characterization. In this section, the potential contaminant sources and a general description of the planned chemical analyses are presented, followed by a description of the sampling plan for each potential source area, and a summary of the quality control sampling program. Additional quality control measures for field sampling and laboratory analysis are presented in the Quality Control Plan.

### **3.1 POTENTIAL SOURCES**

Potential contaminant sources at the site include fuel tanks, waste discharge locations, potential waste storage areas on the surface of the property, and materials that are present in the underground complex. The fuel tanks, which were used to store diesel and propellant, are located adjacent to the underground complex at a depth of approximately 45 ft bgs. Leaks may have occurred from the tanks or from piping connections located below ground surface. Potential waste storage areas on the surface of the property were identified from aerial photos. The ground disturbances observed include possible stains, mounded materials, liquid impoundments, storage containers, and pits. Materials present in the complex which are potential sources include product remaining in tanks and standing liquids.

Based on the previous inspection of the underground complex (Stollar & Associates, et al., 1991), five of the six tanks remaining in the complex are presently sealed. The amount and type of product contained in these tanks are not known. Standing liquids are present in several areas of the complex including the silos, tunnel junction rooms, and piping trenches. The source and quality of these liquids are unknown. Inquiries made to the Air Force by Weston (1990) concerning the handling and storage of radioactive materials indicated that the only source of radioactive materials at the facility was the warhead itself. The radioactive materials within the warhead were contained as a sealed source. Warheads were not stored at the facility except when deployed on top of the missile in the silos. However, radioactive contamination may have resulted from rumoured disposal in the missile silos during the period in which the installation was abandoned and the silo doors were left open.

The possibility of unexploded ordnance remaining at the facility, which was mentioned in the PA, was researched by Stollar & Associates during the development of the RI/FS work plans. The Bennett complex and three other Titan I missile complexes (IA, IB, and IC) were built on the former Lowry Bombing Range. Sections of the range were searched and cleared of unexploded ordnance in 1959 and 1961 (Appendix C). Based on these ordnance clearing activities, the entire bombing range, except for the Titan I complexes, was officially cleared for unrestricted use. Ordnance clearance was

accomplished by walking the surface of the area and removing any unexploded ordnance or fragments as found. The land has subsequently been sold to private interests and is being used for agricultural and ranchette uses. The construction history of the Titan complexes indicated that excavation was held up for a short time at Complex I-B in early 1959 when live ordnance was uncovered (USACE, 1961). Military explosive ordnance disposal units were called to the construction site and cleared the area. No mention was made of any ordnance related construction delays at the BANGF.

The area surrounding the Bennett facility was cleared by the earlier mentioned 1961 unexploded ordnance (UXO) survey conducted by military explosive ordnance disposal units. The Bennett facility was not included in this survey presumably because it was not deemed necessary. The missile facility was fully operational at the time of the survey and it would be logical to assume that all UXO would have been cleared from the site during the construction of the facility considering the magnitude of the excavation for the underground complex. A map of the old Lowry Bombing Range shows that the closest target area at the BANGF was approximately 1 mile to the northwest, consequently the site was not in a high impact zone. Based on this information, additional ordnance clearing activities are not recommended for the area containing the underground complex. However, several borings will be drilled beyond the estimated limits of the former missile complex excavations during the SI fieldwork. UXO investigations will be conducted at these locations to reduce the risk of encountering UXO during drilling activities.

### **3.2 CHEMICAL ANALYSES**

During the SI, field samples will be analyzed for several parameters including volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), metals, total petroleum hydrocarbons (TPH), and PCB, will be conducted during the program. A list of target compounds for the VOC, SVOC, and PCB analyses is presented on Table 31. Table 3-1 also includes the Target Analyte List (TAL) for metals analyses. The type and number of samples for the specific analytes are presented in Section 3.3. Analytical procedures and laboratory QC procedures are presented in the Quality Control Plan. All analytical samples will be disposed by the laboratory in accordance with all applicable state and federal regulations.

Analysis for VOCs and SVOCs will be conducted on samples to screen for a broad range of organic compounds which may have been used at the site. The target analyte list is based on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Target Compound List (TCL) and on target compounds for the EPA methods 8240 and 8270 (USEPA, 1986). The metals which will be analyzed include the 23 metals on the EPA TAL and cyanide. In addition, standing water from the missile silos will be analyzed for gross alpha/beta activity. This analysis will be used for screening purposes. If gross alpha/beta are detected in any of the samples at a concentration greater than 5 pCi/L, a spectral analysis will be conducted to identify the components contributing to the gross alpha/beta activity.

**Table 3-1 Target Compound List/Target Analyte List**

<b>TARGET COMPOUND LIST</b>		
<u>Volatile Organic Compounds</u>		
Acetone	Bis(2-chloroethyl)ether	1,2,4-Trichlorobenzene
Benzene	Bis(2-chloroisopropyl)ether	2,4,5-Trichlorophenol
Bromodichloromethane	Bis(2-ethylhexyl)phthalate	2,4,6-Trichlorophenol
Bromoform	4-Bromophenyl phenyl ether	
2-Butanone	Butyl benzyl phthalate	
Carbon disulfide	4-Chloroaniline	<u>PCBs</u>
Carbon tetrachloride	2-Chloronaphthalene	
Chlorobenzene	4-Chloro-3-methylphenol	Aroclor-1016
Chlorodibromomethane	2-Chlorophenol	Aroclor-1221
Chloroethane	4-Chlorophenyl phenyl ether	Aroclor-1232
2-Chloroethyl vinyl ether	Chrysene	Aroclor-1242
Chloroform	Dibenzo(a,h)anthracene	Aroclor-1245
Chloromethane	Dibenzofuran	Aroclor-1254
1,1-Dichloroethane	Di-n-butylphthalate	Aroclor- 1260
1,2-Dichloroethane	1,3-Dichlorobenzene	
1,1-Dichloroethene	1,4-Dichlorobenzene	
trans-1,2-Dichloroethene	1,2-Dichlorobenzene	
1,2-Dichloropropane	3,3-Dichlorobenzidine	Aluminum
cis-1,3-Dichloropropene	2,4-Dichlorophenol	Antimony
trans-1,3-Dichloropropene	Diethylphthalate	Arsenic
Ethylbenzene	2,4-Dimethylphenol	Barium
2-Hexanone	Dimethylphthalate	Beryllium
Methylene chloride	4,6-Dinitro-2-methylphenol	Cadmium
4-Methyl-2-pentanone	2,4-Dinitrophenol	Calcium
Styrene	2,4-Dinitrotoluene	Chromium
1,1,2,2-Tetrachloroethane	2,6-Dinitrotoluene	Cobalt
Tetrachloroethene	Di-n-octylphthalate	Copper
Toluene	Fluoranthene	Iron
1,1,1-Trichloroethane	Fluorene	Lead
1,1,2-Trichloroethane	Hexachlorobenzene	Magnesium
Trichloroethene	Hexachlorobutadiene	Manganese
Vinyl acetate	Hexachlorocyclopentadiene	Mercury
Vinyl chloride	Hexachloroethane	Nickel
Xylene	Indeno(1,2,3-cd)pyrene	Potassium
	Isophorone	Selenium
<u>Semivolatile Organic Compounds</u>	2-Methylnaphthalene	Silver
	2-Methylphenol (o-cresol)	Sodium
	4-Methylphenol (p-cresol)	Thallium
Acenaphthene	Naphthalene	Vanadium
Acenaphthylene	2-Nitroaniline	Zinc
Anthracene	3-Nitroaniline	
Benzoic acid	4-Nitroaniline	
Benzo(a)anthracene	Nitrobenzene	
Benzo(b)fluoranthene	2-Nitrophenol	
Benzo(k)fluoranthene	4-Nitrophenol	
Benzo(g,h,i)perylene	N-Nitroso-di-n-propylamine	
Benzo(a)pyrene	N-Nitrosodiphenylamine	
Benzyl alcohol	Pentachlorophenol	
Bis(2-chloroethoxy)methane	Phenanthrene	
	Phenol	
	Pyrene	

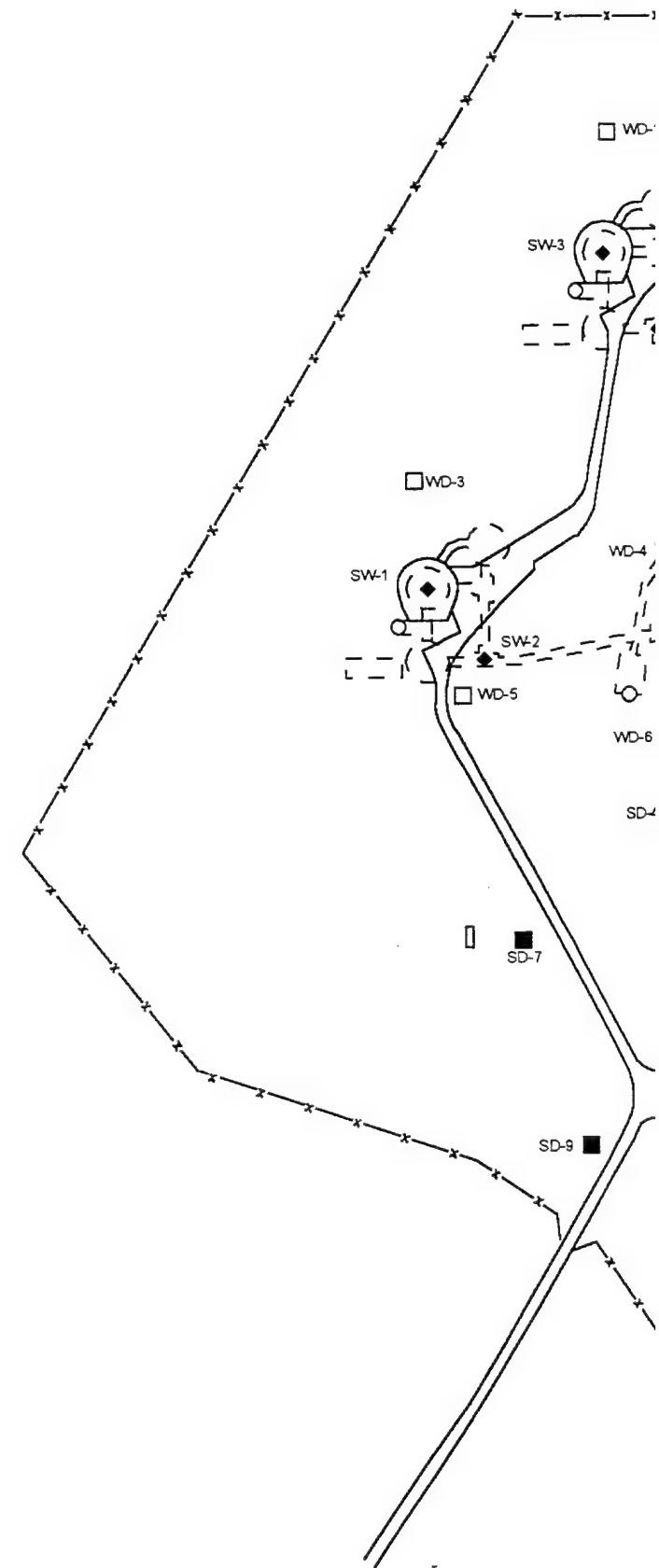
### **3.3 AREA-SPECIFIC SAMPLING PROGRAM**

Proposed sampling locations for the SI are shown on Figure 31. Rationale, sample intervals and analytes for each boring are described by source area in the following sections. The sample locations may be adjusted at the discretion of the field geologist based on the presence of underground utilities or other field observations. During sampling, an organic vapor analyzer (OVA) will be used to measure the concentration of VOCs in the headspace of soil samples as described in Section 4.3.6. Sampling intervals may be changed if concentrations of VOCs in the headspace are above background or if staining is observed in the soils. Tables 3-2 and 3-3 are summaries of samples which will be collected during the program. These samples will be collected in accordance with protocols specified in the Quality Control Plan.

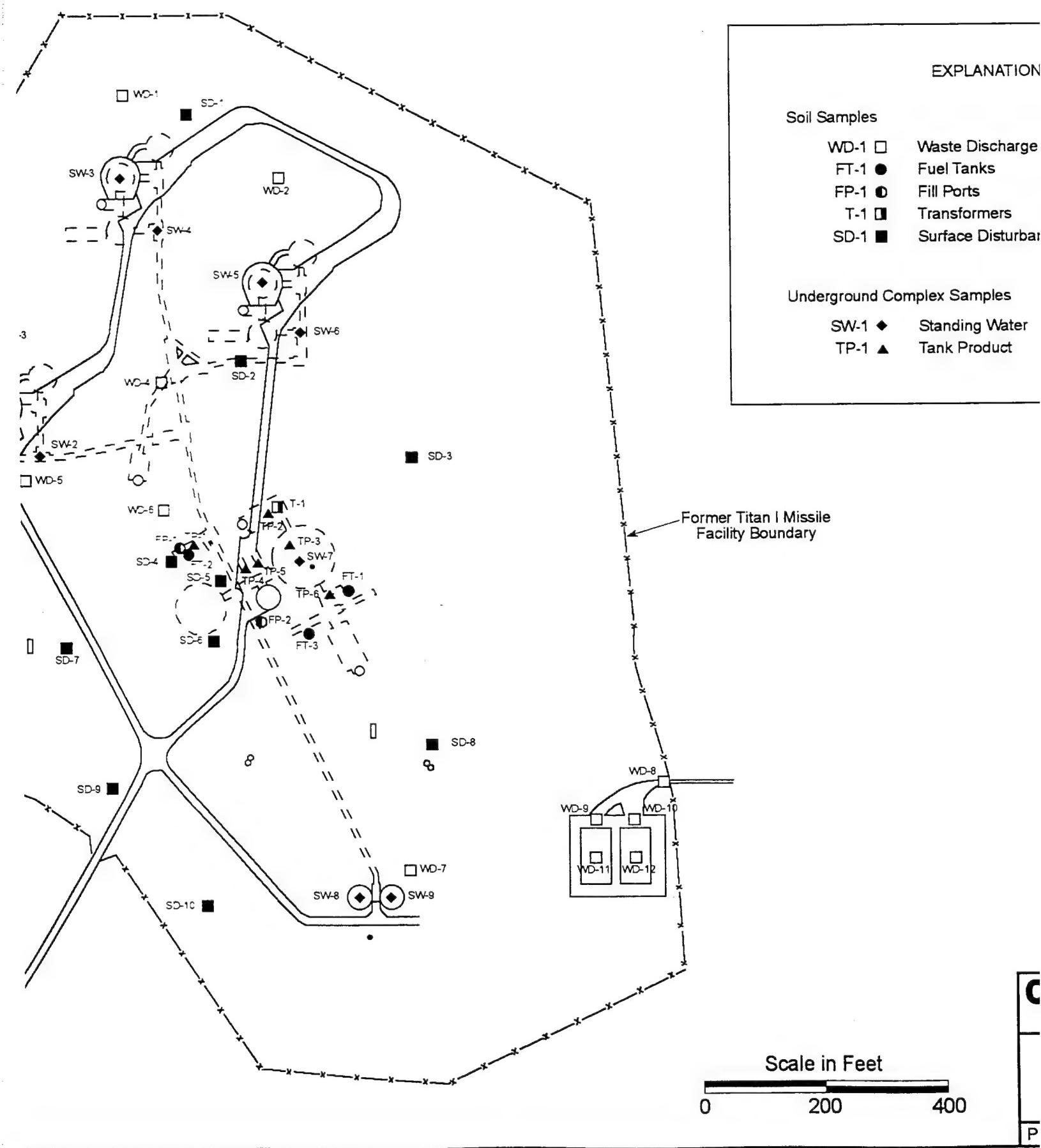
#### **3.3.1 Sewage Stabilization Ponds**

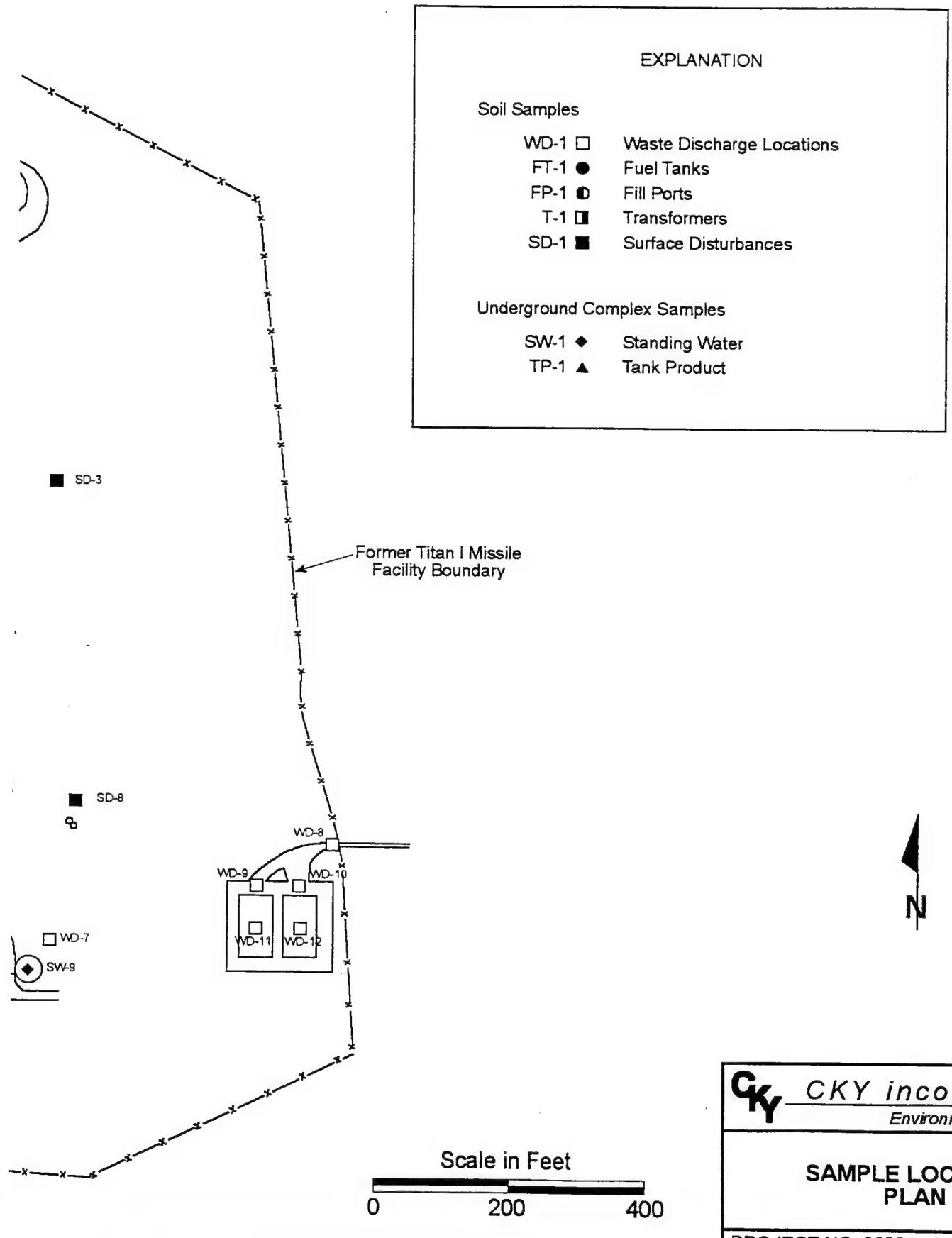
The sewage stabilization ponds are located in the southeast corner of the property. Sewage was ejected from the underground complex and stored in the ponds. No active treatment of the sewage was conducted in the ponds. Liquid was discharged through pipes on the north side of each pond to a drainage channel which flowed east to Kiowa Creek. The sampling program in this area has been designed to characterize the waste ejected from the complex in the sewage system and determine whether any contaminants in the system migrated from the pond area through the surface water drainage.

Five soil borings will be drilled in the vicinity of the sewage stabilization ponds as shown on Figure 3-1. The proposed sample intervals are presented on Table 34. All samples from this source area will be analyzed for VOCs, SVOCs, TPH, and metals. Samples will be collected from each pond, the discharge points, and the drainage ditch. The boring in the east pond will be completed in the uppermost consolidated unit in the Denver Formation, which is estimated to be approximately 30 ft bgs. Samples will be collected at the surface, and at 3, 6, 10, and 30 ft bgs. The boring in the west pond will be drilled to a depth of 10 ft and boring samples will be collected at the surface, 3, 6, and 10 ft bgs. Borings located at the discharge points and the drainage ditch will be drilled to 3 ft bgs and samples will be collected at the surface and at 3 ft bgs.



Source: Weston, 1990





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**SAMPLE LOCATION PLAN**

PROJECT NO. 8802

FIGURE 3-1

**Table 3-2 Soil Sampling Summary**

Source Area	Location	No. of Borings	Depth (ft)	Total No. of Samples	Number of Analyses				
					VOCs	SVOCs	Metals	TPH	PCBs
Sewage Stabilization Ponds	West Pond	1	10	4	4	4	4	4	--
	East Pond	1	30	5	5	5	5	5	--
	Discharge Point	3	3	6	6	6	6	6	--
Waste Discharge Locations	Waste Clarifier Outlet	1	10	4	4	4	4	4	--
	Waste Clarifier Ditch	1	3	2	2	2	2	2	--
	Seal Chamber Outlets	5	3	10	10	10	10	10	--
Fuel Tanks	Former/Current Diesel Tanks	2	60	6	6	6	6	6	--
	RP-1 Tank	1	60	3	3	3	3	3	--
	Fill Ports	6	2 <sup>1)</sup>	2	2	2	2	2	--
Facility	Perimeter	5	160	15	15	15	15	--	--
Transformer	Base of Power Pole	3	2	1	--	--	--	1	1
Surface Disturbances	See Figure 3-1	10	3	10	10	10	10	10	--
Background	See Figure 3-3	2	10	4	4	4	4	4	--
<b>TOTAL</b>		41	--	72	71	71	71	57	1

<sup>1)</sup> May include three additional discrete samples if hydrocarbon staining is observed.

**Table 3-3 Liquid Sampling Summary**

Source Area	Sample Type	Location	Number of Samples <sup>1)</sup>	Number of Analyses			
				VOCs	SvOCs	Metals	TPH
Launch Complexes	Standing Water	Missile Silos	3	3	3	3	--
	Standing Water	Equipment Term.	3	3	3	3	--
	Standing Water	Propellant Term.	3	3	3	3	--
Underground Complex	Standing Water	Antenna Silos	2	2	2	2	--
	Standing Water	Tunnel Junction Rooms	3	3	3	6	--
	Standing Water	Power House	1	1	1	1	--
	Tank	Diesel Tank	1	1	--	1	--
	Tank	Acid Tank	2 <sup>4)</sup>	--	--	1	--
	Tank	Water Tanks	2 <sup>5)</sup>	--	--	2	--
	Tank	RP-1 Tank	1	1	--	1	--
	Perimeter	Groundwater	Monitoring Wells	10	10	10 <sup>3)</sup>	--
		<b>TOTAL</b>		27	27	28	17
						5	3

<sup>1)</sup> Does not include QC samples (see Table 2-5)

<sup>2)</sup> Product identification

<sup>3)</sup> Includes filtered and unfiltered samples

<sup>4)</sup> Field screening will be performed using pH paper

<sup>5)</sup> Performance of laboratory analyses will be contingent on the results of field screening to identify the nature of the product

Table 3-4      Soil Sample Collection Location

Source Area	Location	Number of Borings	Depth (ft)	Sampling Interval <sup>1)</sup>
Sewage Stabilization Ponds	East Pond	1	30	0, 3, 6, 10, 30
	West Pond	1	10	0, 3, 6, 10
	Outlets	2	3	0, 3
	Drainage Ditch	1	3	0, 3
Waste Discharge	Water Clarifier Outlet	1	10	0, 3, 6, 10
	Waste Clarifier Ditch	1	3	0, 3
	Seal Chamber Outlets	5	3	0, 3
Fuel Tanks	Diesel Tanks	2	60	40, 50, 60
	RP-1 Tank	1	60	40, 50, 60
	Fill Ports	6	2	Composite of 3 borings at each site <sup>2)</sup>
Facility	Perimeter	5	160	20, 50, 100
Transformer	Base of power pole	3	2	Composite into 1 sample
Misc. Surface Disturbances	See Figure 3-1	10	3	Selected in field <sup>3)</sup>
Background	See Figure 3-3	2	10	0, 10

<sup>1)</sup> Interval may change based on field observations and screening.

<sup>2)</sup> May include three additional discrete samples if hydrocarbon staining is observed.

<sup>3)</sup> Soil composite within the first 3 ft based on field observations.

### **3.3.2 Waste Discharge Locations**

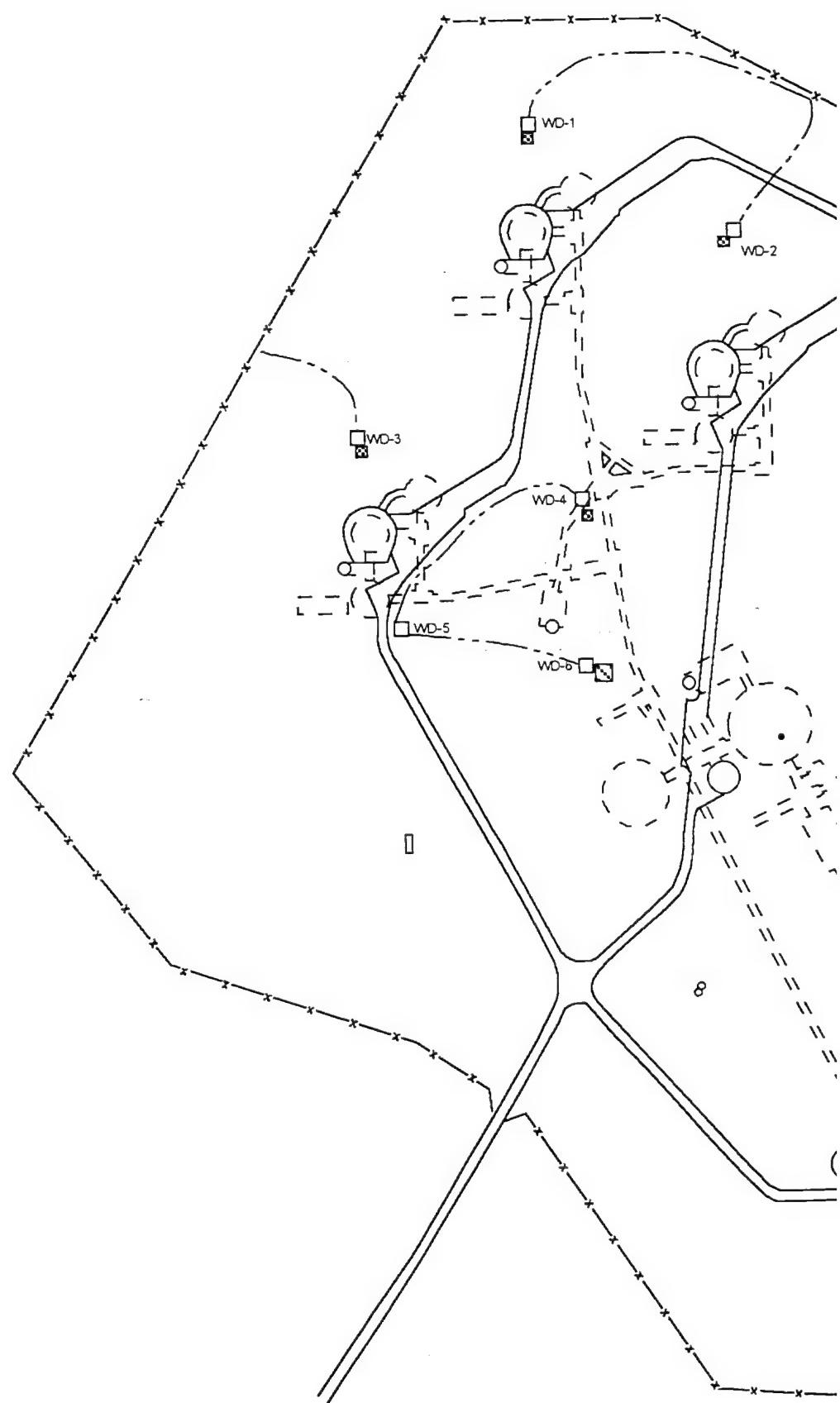
Liquids, including groundwater and surface water, which collected in the facility, were pumped to the surface, treated and released to intermittent tributaries which ultimately discharge into Kiowa Creek. Calcium carbonate, in the form of marble, dolomite or limestone chips, was used to treat the accumulated liquids. Two types of treatment units were employed at the site, which reportedly utilized identical treatment processes. The units were known as chemical waste clarifiers and seal chambers. Drainage ditches leading away from each of the units can be seen in aerial photos of the property (USEPA, 1990). Reportedly, the chemical waste clarifier, which is larger than the seal chambers, was used to treat water from the powerhouse and control center. Standing water can be seen at the discharge point of the clarifier in aerial photos taken while the missile complex was in operation. The seal chambers, which are located near each silo, the antenna terminal and Blast Lock 1, were used to treat water from each of these areas. The objective of sampling in the vicinity of these waste discharge units is to characterize the waste which was discharged and to identify any discharged contaminants which may be present in the soils along the drainage paths.

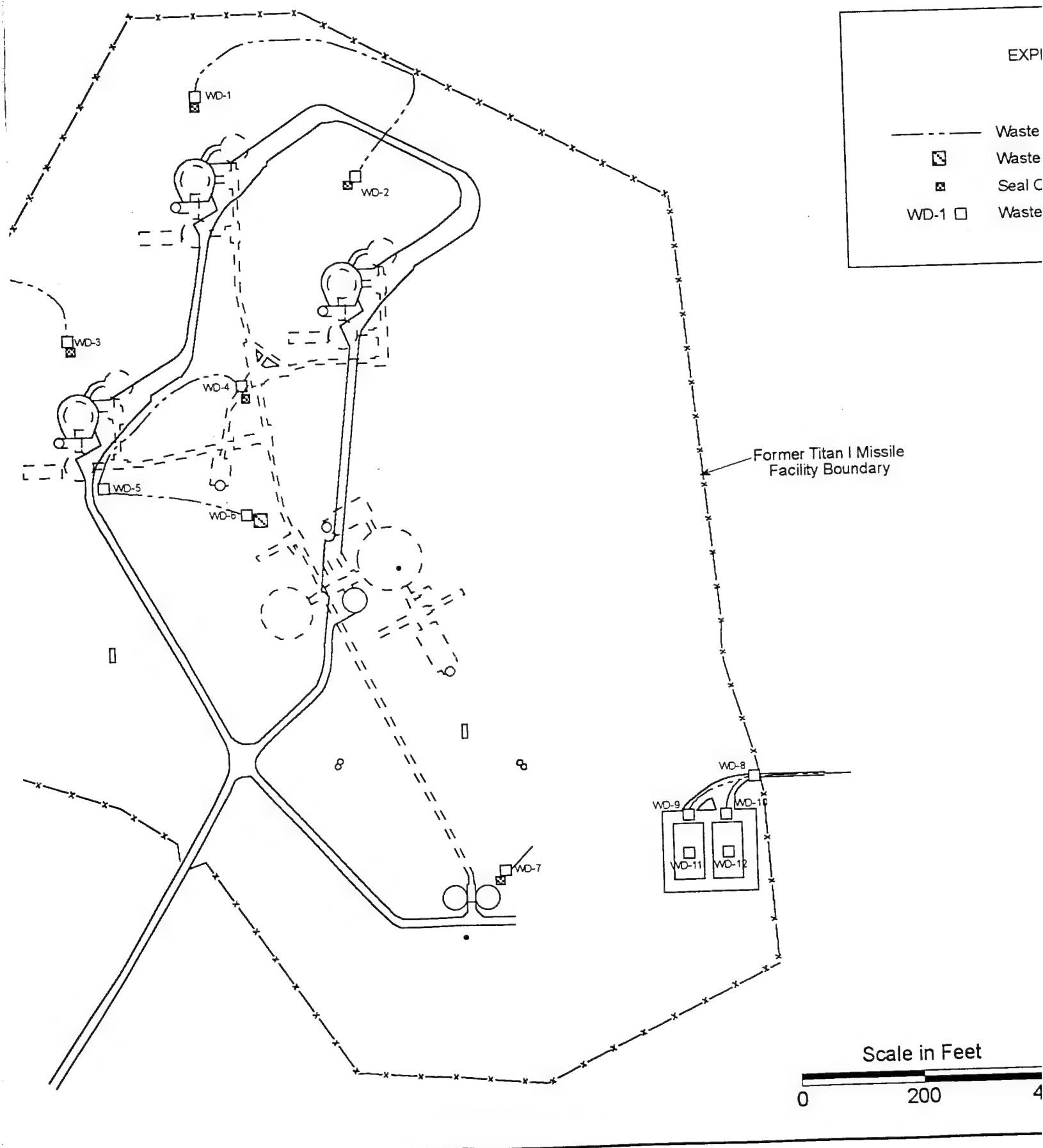
Samples will be collected at the outlet of each unit as shown in Figure 32. A boring will be drilled to a depth of 10 ft at the discharge point of the waste clarifier in the area where water has pooled (WD-6). Samples from this boring will be collected at the surface, and 3, 6, and 10 ft bgs. At the seal chamber discharge points, samples will be collected at the surface and 3 ft bgs. In addition, because of the estimated volume of waste discharged from the waste clarifier, a shallow boring (3 ft bgs) will be drilled in the drainage ditch, approximately 250 ft downstream of the unit (WD-5). All samples collected at waste discharge locations will be analyzed for VOCs, SVOCs, TPH, and metals.

### **3.3.3 Fuel Tanks**

A total of four fuel tanks were utilized at the complex for storage of diesel fuel and RP1 propellant. These tanks were located adjacent to the complex, at the level of the tunnels, approximately 45 ft bgs. Two 67,000-gallon diesel tanks were removed from the site during the salvage operation. A 5000-gallon fuel tank remains in the complex. The RP-1 propellant tank, which has a capacity of 40,000 gallons, is located in the Fuel Terminal, north of the Control Center. The tanks were filled from ports on the surface. One port, which served all three diesel tanks, was located next to the entry portal, and the RP1 tank was filled from a port directly above the tank. Sampling will be conducted to assess whether leaks from the tanks or the associated piping occurred and hydrocarbons are present in the soil.

Three borings will be drilled in the vicinity of the fuel tanks to sample the fill material in the interval between the tanks and the surface of the Denver Formation. One boring will be drilled adjacent to each fuel tank as shown on Figure 31. Samples will be collected at depths of 40, 50 and 60 ft bgs and will be analyzed for VOCs, SVOCs, metals, and TPH. Three borings will be drilled, to a depth of 2 ft, in the area of each of the fill ports, and one composite sample will be collected from each area. However, if hydrocarbon staining is

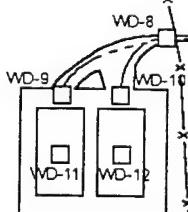




EXPLANATION

- - - Waste Discharge Drainage
- ☒ Waste Clarifier
- ☒ Seal Chamber
- WD-1 □ Waste Discharge Sampling Locations

Former Titan I Missile Facility Boundary



Scale in Feet



<b>CKY</b>	<b>CKY incorporated</b> <i>Environmental Services</i>
<b>WASTE DISCHARGE DRAINAGES</b>	
PROJECT NO. 8802	FIGURE 3-2

observed, the stained interval will be collected for analysis. These shallow samples will be analyzed for TPH.

### **3.3.4 Transformer**

Two transformers remain at the site, mounted on a telephone pole located north of the entry portal. These transformers possibly contained PCBs, which was a commonly used electrical fluid at the time the complex was in operation. The transformers have been vandalized and have been shot with bullets. Samples will be collected in this area to determine whether PCB containing hydrocarbons have leaked out of the units onto the ground below.

Three borings will be drilled at the base of power pole to a depth of 2 ft. Soil from these borings will be composited into 1 sample unless obvious hydrocarbon staining is observed. If obvious hydrocarbon staining is observed, a maximum of three discrete soil samples will be collected from each of the three boring locations. The sample(s) will be analyzed for TPH and PCBs.

### **3.3.5 Miscellaneous Surface Disturbances**

A series of aerial photographs of the facility, which date from 1937 through 1985 (USEPA, 1990), was reviewed during the preliminary assessment (Weston, 1990) and the development of the RI/FS sampling program (Stollar & Associates, et al., 1991). Surface disturbances such as possible ground stains, ground scars, containers, impoundments, standing liquid, trenches, and mounded material were identified based on the aerial photograph review. Documentation and visual ground inspection have provided no useful information concerning the disturbances. Sampling at these locations will be conducted to evaluate whether wastes or other hazardous materials were stored on the surface of the facility and to characterize these wastes.

Ten sites will be sampled as shown on Figure 3-1 based on locations identified by aerial photography and described in the preliminary assessment (Weston, 1990). The samples will be collected from the upper 3 ft of soil and the interval to be analyzed will be selected by the field geologist, based on visual observations and the results of field measurements. The samples will be analyzed for VOCs, SVOCs, metals, and TPH.

### **3.3.6 Launch Complexes**

Three launch complexes are present in the northern portion of the BANGF. As previously stated, the launch complexes are identical in construction and contain a missile silo, propellant terminal, and an equipment terminal. Standing water was observed in each of the launch complex structures during a site visit for the preparation of the RI/FS work plans. The quality and source of the standing water is unknown. Potential contaminants that may be present in the standing water include fuel and propellant products, solvents, and metals. In addition, the presence of radioactive in the standing water in the missile silos from rumoured disposal activities will also be evaluated. Samples of the standing

water in each of the launch complex structures will be collected to document the water quality to determine if treatment of the water will be required for closure or transfer of the property. Each of the standing water samples will be analyzed for VOCs, SVOCs, and metals. The samples collected from the missile silos will also be analyzed for gross alpha/beta activity.

### **3.3.7 Underground Complex**

Potential contaminant sources which exist within the underground complex include product remaining in tanks and standing water. The tanks remaining in the complex include the 5,000-gallon diesel tank, two tanks which are part of the demineralizing system located in the north side of the powerhouse, the RP-1 propellant tank, and two water-storage tanks.

During a facility inspection for the preparation of the RI/FS work plans, standing water was observed in the antenna silos, the tunnel junction rooms and beneath the floor in the powerhouse. Based on the laboratory results of bulk insulation samples collected in the underground complex, the standing water will be considered contaminated with asbestos. Other possible contaminants in the water include components which were used in the complex when it was operational, such as fuel products, metals, and solvents. Samples of the standing water will be collected to evaluate the source and quality of the water and to evaluate whether treatment of the water will be necessary for closure of the facility. The samples will be collected as grab samples using stainless steel or Teflon utensils if possible. Standing water samples will be collected from beneath the powerhouse floor, each antenna silo, and three tunnel junction rooms in the launch complex area. The samples will be analyzed for VOCs, SVOCs, metals, and TPH.

Samples will be collected from any material remaining in the tanks to characterize the product and assess possible disposal mechanisms. Liquids were observed in the 5000-gal diesel tank during the RI/FS site visit (Stollar & Associates, et al., 1991). The liquids will be sampled and analyzed for VOCs, SVOCs, TPH, and product identification. Any liquid present in the RP-1 propellant tank will be sampled and analyzed for VOCs, SVOCs, TPH and product identification. Initial samples of any product in the remaining tanks will be screened using field instruments before laboratory analysis is requested.

Liquids remaining in the water storage tanks and any liquid that may be present in the tank in the air-filtration facility will be visually inspected and screened with an OVA and the pH and conductivity of the liquid will be measured. A line leading to the tank in the airfiltration facility marked "UA" (possibly unfiltered air) may indicate that the tank was used for compressed air. If results of the field screening tests indicate that the liquid may not be water, a sample will be sent to the lab for analysis.

Liquids remaining in the demineralizing system tanks will be screened first using pH paper. Field tests to identify the type of acid present will be conducted by adding barium chloride to the sample for identification of sulfuric acid, and silver nitrate for identification of hydrochloric acid. The second demineralizing system tank is reported to contain sodium hydroxide. Field tests will be made to determine the pH of any remaining liquids.

### **3.3.8 Perimeter Groundwater Monitoring Wells**

Five groundwater monitoring wells will be installed at the perimeter of the installation to measure the groundwater elevation and flow direction beneath the site, and to assess if contaminants from the BANGF are being transported beyond the property boundaries. A review of available information indicates that the water table at BANGF is at least 100 ft bgs and that groundwater flow in the vicinity of the site is north-northeasterly. Based on this information, it is estimated that the monitoring wells will be drilled to depths of approximately 160 bgs. Three of the wells will be located in the northern and northeastern portions of the installation, downgradient of the potential source areas. The remaining two wells will be located upgradient of the potential source areas, in the southern and southwestern portions of the installation. Well locations are shown on Figure 3-3.

Soil samples will be collected from the borings at or near the land surface and incrementally at 5-foot depths, and at any horizon where contamination is observed or suspected, until completion of the borings. Volatile organic vapor present in the headspace of the soil samples will be measured using an OVA. A discussion of the headspace analysis procedures is presented in Section 4.3.6. Based on field measurements and observations, three soil samples will be selected from each well location for chemical analysis. Analyses will include VOCs, SVOCs, and metals.

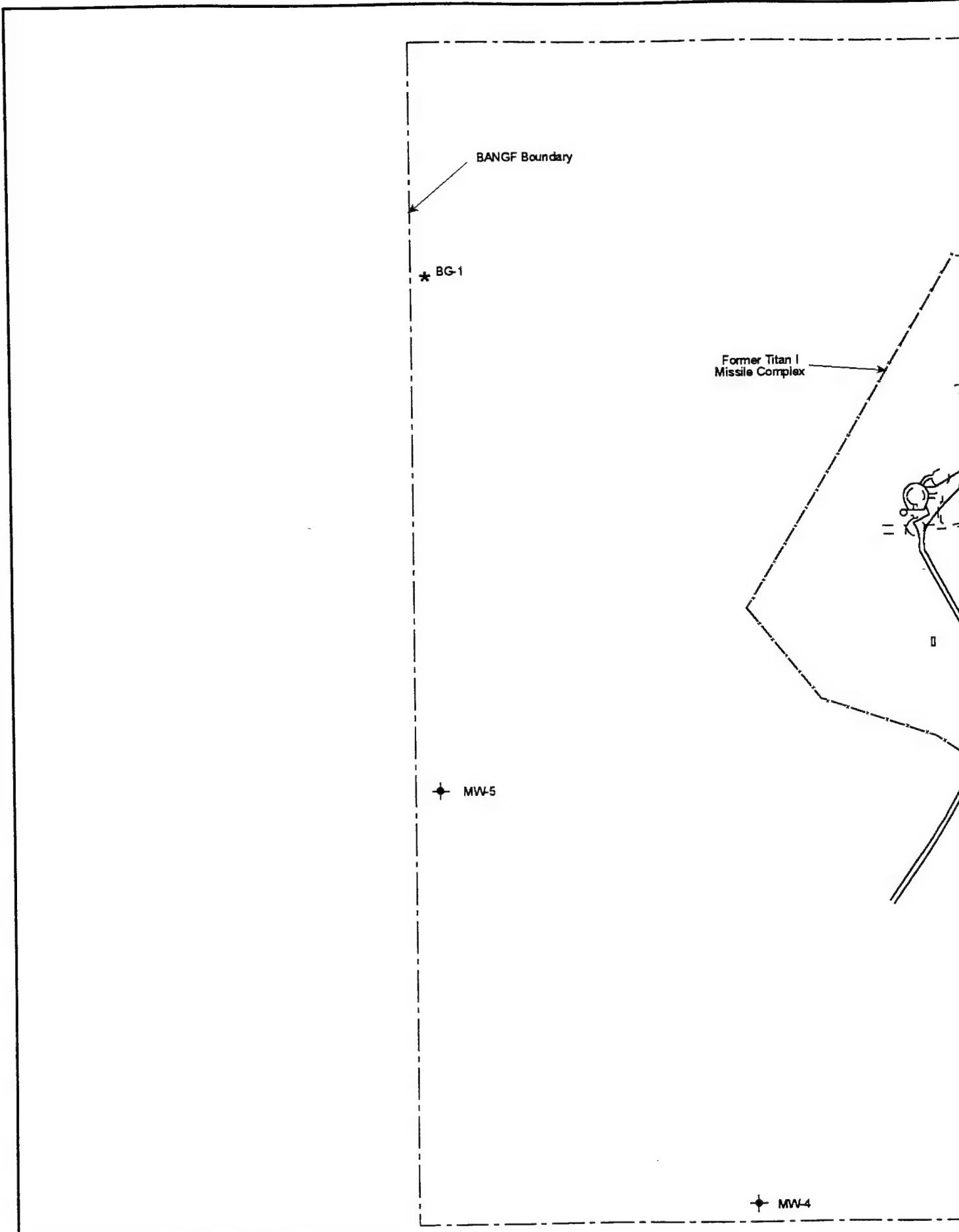
Upon completion of the well installation and well development, groundwater level measurements, aquifer tests, and two rounds of groundwater sampling will be conducted. The aquifer tests will consist of slug tests as described in Section 4.4.5. Potential contaminants in the groundwater include fuel products, metals, and solvents. Groundwater samples will be analyzed for TPH, VOCs, SVOCs, and metals.

### **3.3.9 Background Samples**

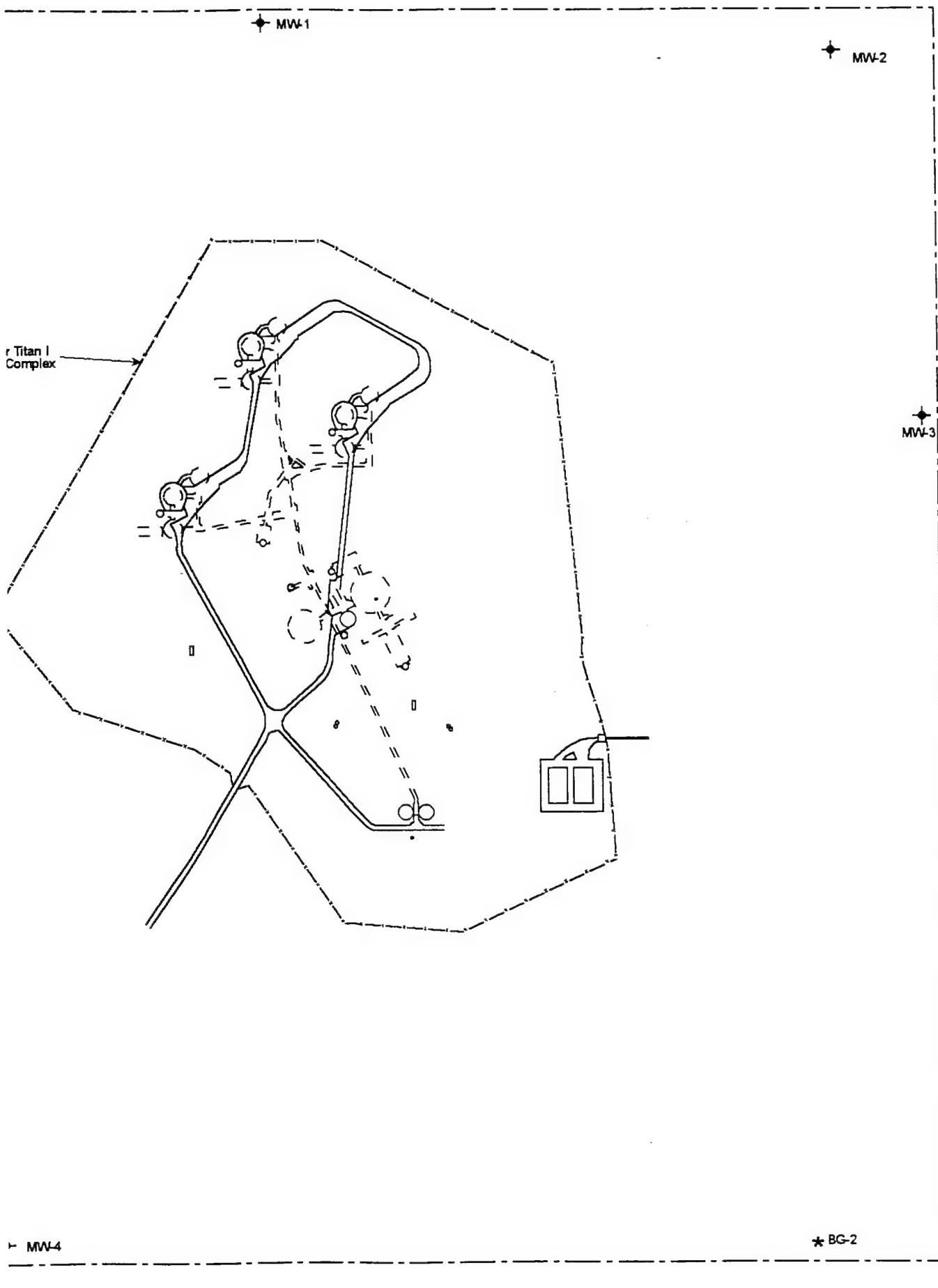
Background samples will be collected to establish baseline soil chemistry data. These data will be compared with analytical data from the potential source areas and migration pathways. Two borings will be drilled in the northwest and southeast portions of the site, respectively, for the collection of background samples (see Figure 3-3). The borings will be drilled to depths of 10 ft and sampled at the surface and 10 ft bgs. Background samples will be analyzed for VOCs, SVOCs, metals, and TPH.

## **3.4 QUALITY CONTROL SAMPLES**

Quality control samples will be collected during the field program to monitor the precision, accuracy, and reproducibility of field sampling and handling techniques. These samples include duplicates, field blanks, trip blanks and rinsate blanks. Twenty QC samples (or about 20 percent of total samples) will be collected during the program, as shown on Table 3-5. One set of QC samples, including a duplicate, trip blank, field blank, and rinsate blank, will be collected for each type (soil and water) of samples. These samples will be analyzed for the same parameters as the corresponding field samples.



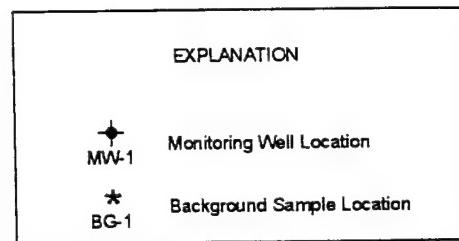
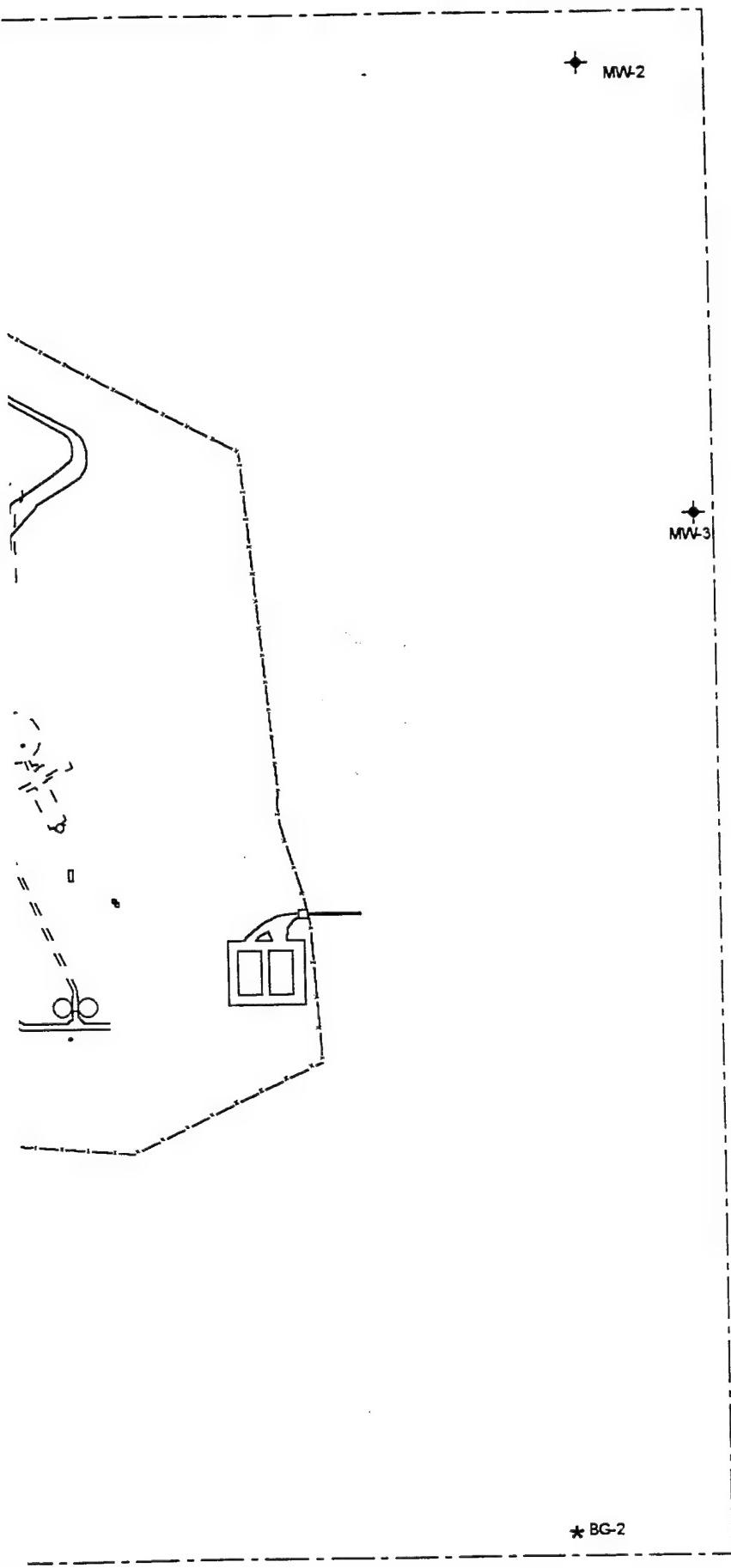
Source: Weston, 1990



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MC  
L

PROJECT N



N

Scale in Feet  
0 200 400

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**MONITORING WELL  
LOCATION PLAN**

PROJECT NO. 8802

FIGURE 3-3

**Table 3-5     Quality Control Sampling Summary**

	Duplicate	Rinsate Blank	Trip Blank	Field Blank	Total
Soil	3 <sup>1)</sup>	3	2	2	10
Groundwater/ Standing Water	3	3	2	2	10

<sup>1)</sup> Soil duplicates will be split at the laboratory.

## **4.0 FIELD SAMPLING PROCEDURES AND EQUIPMENT**

This section details the mobilization, site access, field procedures, sampling protocols, equipment requirements, and operations that will be used during the BANGF SI. Laboratory requirements for sample analysis are provided in the Quality Control Plan.

### **4.1 MOBILIZATION**

Prior to the start of the field activities, arrangements will be made for an adequate communication system linking field teams to each other and to technical, QA, and health and safety management personnel. In addition, sanitation facilities such as portable toilets and wash stations will be set up and provisions made to obtain an adequate water supply for decontamination and other sampling needs. The decontamination area will also be established at this time.

The water supply which will be used during the SI will be sampled and approved by USAEC before the sampling program begins. If possible, the water will be from an aquifer which is greater than 200 ft bgs and is upgradient of potential contaminant sources. In addition, the water should be untreated and unfiltered, and the tap should be accessible at all times. Water for the field program may be procured from the Town of Bennett Water Department or from one of the residences located near the facility. Bennett water is pumped from five wells in the town. Each well has an attached chlorinator, which may be bypassed if necessary. Chemical analysis of either water source will be required prior to the field program.

Copies of the work plan package including the Sampling and Analysis Plan, Quality Control Plan, and the Health and Safety Plan will be distributed to all field personnel. An orientation will be conducted to familiarize the team with the site, the sampling program, the QA, and health and safety protocols established for the investigation.

### **4.2 SITE ACCESS**

The BANGF is located in a remote area; however, no fence or other structure to limit access to the facility is present. Access to work areas, such as drilling operations, will be controlled by the use of stakes and visible flagging tape.

The underground complex will be accessed through the entrance hatch located adjacent to the entry portal in the central portion of the former Titan missile complex. During the site visit for the preparation of the SI work plans conducted on June 30, 1994, the concrete entrance hatch cover was secured in the open position with a wooden plank. Two large concrete blocks were observed in the entrance way preventing access to the complex. Plans are currently being considered for the construction of a temporary structure over the entrance hatch by the U.S. Army Corps of Engineers. If this structure is not erected prior to the SI field investigation, a crane will be used to remove the concrete blocks from the entrance. The crane will remain on site throughout the sampling investigation of the

underground complex to secure the hatch cover in the open position. The crane will also be used to close the hatch cover at the end of each day to prevent access to the underground complex by unauthorized individuals.

## **4.3 SUBSURFACE EXPLORATION AND SOIL SAMPLING**

Soil samples for laboratory analysis, lithologic description and/or headspace analyses will be collected during the BANGF SI using a combination of hand auger, hollow stem auger, and air rotary techniques.

Before the soil sampling program begins, drilling locations will be screened for the presence of underground utilities or other structures. All utilities at the site are disconnected; however, safety hazards from drilling into concrete or metal structures still exist. Geophysical techniques may be ineffective at the site because of the large amount of underground equipment; therefore, the sites will be cleared primarily by review of engineering drawings. In addition, UXO investigations, as described in Section 4.3.1, will be conducted at boring locations that lie beyond the limits of the former missile complex excavations.

### **4.3.1 Unexploded Ordnance Investigation**

As mentioned earlier, UXO are not considered a concern in the immediate vicinity of the underground missile complex due to the magnitude of the excavation required during construction. However, many borings that will be drilled during the SI will be located beyond the estimated limits of the excavations. UXO investigations will be performed at each of these locations to reduce the risk of encountering UXO during drilling activities. Table 4-1 presents the boring locations of concern, the proposed depths, and the type of investigation that will be performed. The locations of these borings are shown on Figure 3-1.

A visual surface clearance of a 15-foot wide lane to each boring location will be conducted to allow safe access for the drill rig. In addition, an area 50 feet in diameter will be cleared at each boring location to accommodate maneuvering of the drill rig. The "cleared" area will be marked using wooden stakes, engineering tape, and pin flags. All activities associated with drilling each boring will be conducted within the marked area.

Borings that will be drilled to depths greater than 3 feet bgs will be cleared to a depth of 2 feet using a Schonstedt magnetometer. The boring will be drilled to a depth of 2 feet, the augers will be removed from the hole, and the drill rig will be moved away to avoid interference with the location equipment. The magnetometer will then be used to clear the location to a depth of 4 feet. The drill rig will be pulled back over the hole and will drill to a depth of 4 feet. Once the 4-foot level is reached, the process will be repeated every 4 feet using Schonstedt MG-220 down hole gradiometer to the desired drill depth or to a depth of 28 feet, whichever is less. Between the 12-foot level and the completion of the boring, the augers will be removed, but the drill rig will not be required to move away from the hole while gradiometer is in use.

Table 4-1      Boring Locations Requiring UXO Investigation

Boring Location	Total Depth (feet)	Investigation Method	Equipment
MW-1	160	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
MW-2	160	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
MW-3	160	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
MW-4	160	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
MW-5	160	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
BG-1	10	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
BG-2	10	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
WD-8	3	Surface Survey	Schonstedt Magnetometer
WD-9	3	Surface Survey	Schonstedt Magnetometer
WD-10	3	Surface Survey	Schonstedt Magnetometer
WD-11	10	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
WD-12	30	Down Hole Geophysics	Schonstedt MG-220 Gradiometer
SD-3	3	Surface Survey	Schonstedt Magnetometer
SD-8	3	Surface Survey	Schonstedt Magnetometer
SD-9	3	Surface Survey	Schonstedt Magnetometer
SD-10	3	Surface Survey	Schonstedt Magnetometer

A surface check will be performed at the locations of borings that will be drilled to depths of 3 feet bgs. These locations will be "cleared" using a Schonstedt magnetometer.

The rationale for the 2-/4-foot magnetometer check is based on the type of ordnance reportedly fired/dropped in the area and the capabilities of the location equipment. Available records indicate that the former Lowery Bombing Range was used for air-to-ground gunnery and precision bombing practice. Aircraft rounds will normally not penetrate more than 2 feet, while bombs will normally not penetrate beyond 25 feet.

If a metallic object is encountered during drilling, the hole will be immediately abandoned using the procedures discussed in Section 4.3.7. The USAEC Project Manager will be notified of the location of any detected unidentified metallic anomalies. A new boring will be initiated a safe distance away from the first location.

#### **4.3.2 Hand Auger Borings**

Shallow soil borings (0 to 5 feet bgs) will be drilled with a 3.5-inch outside diameter (OD) hand auger, if possible. This technique is useful for shallow or surface soil sampling, drilling in areas that are inaccessible to mechanized drill rigs, and drilling in areas that are suspected to contain uncharted or unmarked utilities. Hand-auger drilling uses a stainless steel bucket auger, attached to a rod with a T-shaped handle. Drilling will be accomplished by simultaneously applying downward force and rotating the handle. When the bucket is full, soil cuttings will be removed by withdrawing the bucket auger from the borehole and emptying the contents onto heavy-duty polyethylene sheeting.

Samples can be collected as grab samples from the soil cuttings generated during drilling, or for discrete, undisturbed samples for analysis of volatile compounds, a handdriven hammer sampler will be used. The drive samples will be collected by placing a 6-inch stainless steel sleeve inside the hand auger sampler. The sampler will then be lowered to the bottom of the borehole and advanced into the soil 6 inches with a hand operated slide hammer. The sampler will be withdrawn from the borehole and the sleeve will immediately be removed from the sampler. The ends of the sleeve will be covered with Teflon sheets and plastic end caps. The caps will be secured in place with Teflon tape and the sample will be labeled and placed in an ice chest cooled to  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ .

#### **4.3.3 Hollow-Stem Auger Borings**

Boreholes greater than 5 feet bgs will be drilled using nominal 6-inch OD, continuous flight hollow-stem augers operated from a truck mounted drilling rig. The drill rig will be of sufficient size and capacity to drill borings to a minimum depth of 60 feet bgs. The hollow-stem auger drilling method involves the construction of a borehole by simultaneously rotating and axially advancing the auger column into unconsolidated or poorly consolidated formations. As the augers are rotated and advanced into the ground, they act as a temporary casing, stabilizing the walls of the borehole. A pilot bit and teeth attached to the end of the lead auger does the drilling and directs the soil cuttings to the auger flights. As

the augers are rotated, the cuttings are brought to the surface by the continuous flights on the outside of the hollow stem.

Soil samples will be obtained by attaching a 2.5-inch OD split spoon sampler to a metal rod that will be lowered down the center of the augers. The sampler will contain four 6-inch stainless steel sleeves. The sampler will be driven into the undisturbed soil at the bottom of the borehole a minimum of 18 inches using a 140-pound down hole hammer dropped a distance of 30 inches. The number of hammer blows required to drive the sampler each six inch interval will be recorded to estimate the relative density of the soil. The sampler will be withdrawn from the borehole and opened. The first stainless steel sleeve from the lead end of the sampler will immediately be removed and the ends will be covered with Teflon sheets and plastic end caps. The caps will be secured in place with Teflon tape and the sample will be labeled and placed in an ice chest cooled to  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Soil from the second sleeve from the lead end of the sampler will be sealed in a wide mouth glass jar for headspace analysis as described in the 4.3.6.

#### **4.3.4 Air Rotary Borings**

A total of five monitoring wells will be installed to estimated depths of 160 feet bgs at the perimeter of the BANGF. A dual wall reverse circulation air rotary drill rig equipped with 10-inch OD augers will be used to drill the boreholes for these monitoring wells. Air rotary drilling is a technique which uses air alone to lift cuttings out of the borehole. A rig-mounted compressor provides a large volume of filtered air which is piped down the drill stem and forced out of the drill bit, cooling the bit and lifting the cuttings. In dryair drilling, the cuttings are blown up the outside of the borehole and collect at the surface. When using this procedure, a surface casing may be required to prevent the borehole from caving or eroding. In reverse air circulation methods, cuttings move up the drill stem and are carried to a centrifugal separate (cyclone). Cuttings are discharged from the bottom of the cyclone into bins or drums, and air exits the top.

Soil samples will be collected from the air rotary borings using techniques similar to those used for the collection of samples from hollow-stem borings. When the appropriate sampling depth is reached, a 2.5-inch OD split spoon sampler containing four 6-inch stainless steel sleeves will be lowered to the bottom of the borehole. The sampler will be driven into the undisturbed soil a minimum of 18 inches using a 140-pound down hole hammer dropped from a distance of 30 inches. Upon retrieval of the sampler, the first stainless steel sleeve from the lead end will immediately be removed and the ends will be covered with Teflon sheets and plastic end caps. The caps will be secured in place with Teflon tape and the sample will be labeled and placed in an ice chest cooled to  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Soil from the second sleeve from the lead end of the sampler will be sealed in a wide mouth glass jar for headspace analysis.

#### **4.3.5 Borehole Logging**

While the drilling is being performed, the site geologist will record, at a minimum, the following information on a field boring log (Figure 4-1):

BORING LOCATION				ELEVATION AND DATUM					
DRILLING AGENCY/ DRILLER				DATE STARTED	DATE FINISHED				
DRILLING EQUIPMENT				COMPLETION DEPTH (ft)	DEPTH TO BEDROCK (ft)				
HAMMER WEIGHT/ DROP DISTANCE				DIAMETER OF BORING (in.)	DIAMETER OF WELL (in.)				
TYPE OF WELL CASING			SCREEN PERFORATION		SCREEN INTERVAL (ft)				
TYPE/SIZE OF FILTER PACK			TYPE/THICKNESS OF SEALS						
WATER DEPTH (ft)				LOGGED BY	CHECKED BY				
TIME	PID (ppm)	BLOW COUNT (per foot)	SAMPLE NUMBER	SAMPLE INTERVAL	DEPTH (ft)	LITHOLOGY	WELL CONSTRUCTION	DESCRIPTION OF SUBSURFACE MATERIALS	
					5 10 15 20 25 30				



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Project Name:

Project No.:

## LOG OF BORING NO.

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Figure



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## FIELD BORING LOG

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FIGURE 4-1

- Depths recorded in feet and tenth of feet.
- The estimated interval by depth for each sample taken, classified, and/or retained. For each sample, the length of sample interval and length of sample recovery will be recorded. The sampler type and size (diameter and length) will be recorded.
- Soil classification determined in the field at the time of sampling by the geologist, in accordance with the Unified Soil Classification System. Field soil classification is subject to change based on laboratory test and/or subsequent review. Any such changes will be incorporated in the project report.
- A full lithologic description of each soil sample taken, including a description of all field observations such as the presence of odor, stains, roots, etc.
- The results of the headspace analyses, noting headspace and background reading in ppm.
- A record of soil samples selected for laboratory analysis.
- The use of all drilling additives (including water), noting the amount added and the brand name. The source of water for drilling mud must be clean and will be recorded.
- A description of drilling equipment used; including a record of its manufacturer, model number, bit size (corresponding to actual borehole diameter), and auger size.
- A record of the drill sequence and activities.
- A record of all special problems and their solutions; e.g., hole squeezing, recurring problems at a particular depth, or unrecovered tools in the hole.
- The date for the start and completion of borings along with a notation by depth for drill crew shifts and individual days.
- Each sequential boundary between the various soils and individual lithologies, noted by depth. When depths are estimated, the estimated range will be noted along the boundary.
- The depth of first-encountered free water, along with the method of determination.
- Applicable health and safety monitoring results, such as organic vapors or combustible gas which are present above background level in the borehole.

#### **4.3.6 Headspace Analysis**

During drilling, headspace analysis will be performed on soil samples as a gross assessment of potential contamination. Volatile organic vapor present in the headspace of soil samples will be measured using an OVA. These measurements will be obtained from soil samples in the following manner:

- A portion of the soil sample collected will be placed in a clean wide mouth glass jar filled approximately half full;
- The jar will be sealed with Teflon film, or aluminum foil, capped and labeled;
- The samples will be allowed to sit for at least 15 minutes so soil gases can equilibrate with the air in the headspace of the jar;
- The headspace will be tested for volatile organic vapor with an OVA; and
- Headspace and background readings will be recorded in ppm on the individual boring logs.

#### **4.3.7 Borehole Abandonment**

Upon completion of soil sampling activities, boreholes that will not be completed as monitoring wells will be abandoned to seal any subsurface conduit from surface infiltration. The seal will consist of a grout cement mixture composed by weight of 20 parts cement (Portland II or V) to 1 part bentonite (approximately 5 pounds) with a maximum of 8 gallons of approved water per 94-pound bag of cement. The grout will be pumped into place with a ridged tremie pipe lowered through the inner annulus of the augers. The augers will be removed as the grout is placed. This procedure will continue until undiluted grout flows from the boring at the ground surface. The borehole will be checked after 24 hours to see if the grout has settled. If settlement has occurred, additional grout will be added until firm grout is present at the land surface.

Documentation of borehole abandonment procedures will be maintained on the field boring log for each location and in the daily log of events.

### **4.4 MONITORING WELL INSTALLATION AND GROUNDWATER SAMPLING**

Five groundwater monitoring wells will be installed at the perimeter of the BANGF. The monitoring wells will be constructed within the borings drilled to estimated depths of 160 feet bgs using reverse circulation air rotary drilling techniques.

#### **4.4.1 Well Construction**

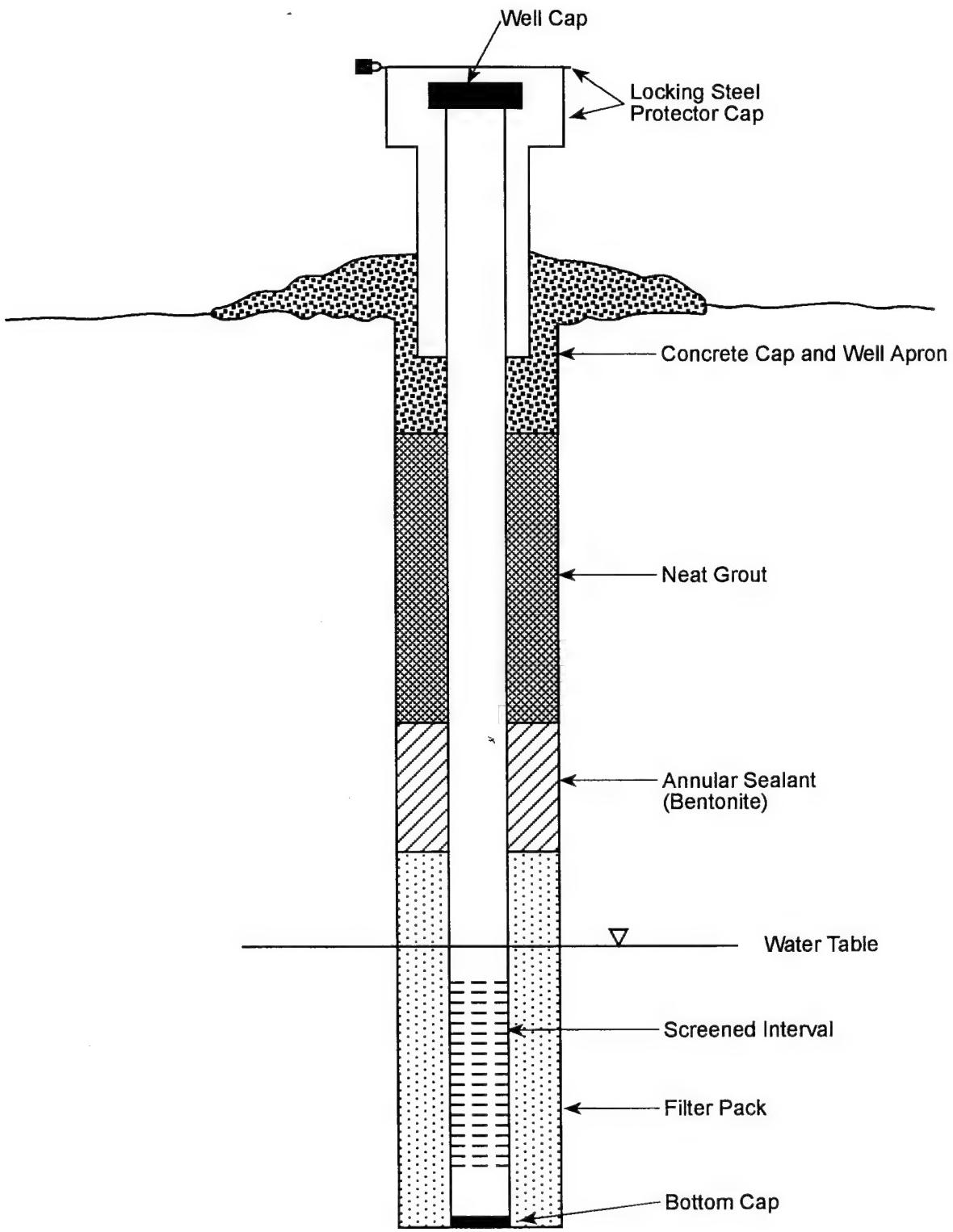
Monitoring wells will be constructed of 4-in OD, flush threaded, Schedule 40, PVC casing. A typical well-construction diagram is presented in Figure 4-2. The final well-construction details will be determined after hydrogeologic conditions are better known. These details include total well depth, screen slot size, screen length, and filter pack material. The Project Manager shall approve the well construction details prior to construction of the well. Well completion depth will be decided based on the depth to groundwater and the saturated thickness of the aquifer. Well screen lengths will be determined by the thickness of the saturated interval to be screened. In general, screens will be 20 feet long, beginning approximately 2 to 3 feet below the water table. Screen slot size will be decided based on field sieve analysis of soil samples. All casing joints will be flush threaded and no solvents or cements will be used on the PVC. Teflon tape may be used as a pipe joint filler, if required. All pipe and screen will be steam-cleaned before use. Wells will be completed above grade and the well head will be encased with an 8inch steel security casing with a locking lid. Well construction information will be recorded on a WellConstruction Summary form (Figure 4-3).

Once the borehole is drilled to the total depth needed, the well will be installed in the annular space within the steel outer casing. The well casing will be suspended off the borehole bottom by a cable on the drilling rig attached to the well head. Stainlesssteel casing centralizers will be placed at the top and bottom of the screen to ensure an even distribution of the filterpack. The filterpack will be placed in the annular space from the base of the well screen to a level 2 to 5 ft above the top of the screen. A bentonite seal, 2 to 5 ft thick and composed of 3/8 to 1/2 in pellets, will be placed above the filterpack and the remaining annular space will be filled with a neat cementbentonite grout. The grout will be well mixed and free of lumps. If the bentonite seal or grout is being placed below the water table it will be pumped to the appropriate level with a tremmie pipe if pellets cannot be used.

#### **4.4.2 Well Development**

Prior to well development, the water level and well depth will be measured from a permanently marked point on the well casing using an electric sounding device and weighted tape. The water level will be recorded to the nearest 0.01 inch on the water level form provided in Figure 4-4.

Well development will be performed on each of the five wells to remove finegrained material from the well screen, filter pack, and formation near the well, and to evacuate any fluid introduced downhole during drilling or well construction such as drilling mud and fresh water. By removing fine-grained material the porosity and permeability of the nearby formation increases, the filter pack is stabilized, and a hydraulic connection between the well and the aquifer is assured.



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**GENERALIZED WELL  
CONSTRUCTION DIAGRAM**

PROJECT NO. 8802

FIGURE 4-2

PROJECT \_\_\_\_\_ WELL NO. \_\_\_\_\_  
PERSONNEL \_\_\_\_\_  
LOCATION OR COORDS. \_\_\_\_\_ ELEVATION: GROUND LEVEL \_\_\_\_\_  
\_\_\_\_\_ TOP OF CASING \_\_\_\_\_

DRILLING SUMMARY		CONSTRUCTION TIME LOG				
		TASK	START		FINISH	
TOTAL DEPTH		DRILLING:	DATE	TIME	DATE	TIME
BOREHOLE DIAMETER						
DRILLER						
RIG						
BIT(S)		GEOPHYSICAL LOGGING:				
DRILLING FLUID						
SURFACE CASING						
WELL DESIGN						
BASIS:	GEOLOGIC LOG GEOPHYSICAL LOG	WELL DEVELOPMENT	SCREEN PLACEMENT:			
CASING STRING (S): C - CASING S - SCREEN			FILTER:			
			SEAL:			
			GROUT:			
			DEVELOPMENT:			
			OTHER:			
CASING C1		WELL DEVELOPMENT				
C2						
C3						
C4						
SCREEN S1		COMMENTS				
S2						
S3						
S4						
FILTER MATERIAL:						
SEAL:						
GROUT:						
OTHER:						

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## **WELL CONSTRUCTION SUMMARY**

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**FIGURE 4-3**

Project Number

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## WATER LEVEL MEASUREMENT SHEET

FIGURE 4-4  
PROJECT NO. 8802

FIGURE 4-4  
PROJECT NO. 8802

SITE TYPE	SITE ID
WELL	

DEPTH TO BOTTOM (INITIAL) \_\_\_\_\_

(FINAL) \_\_\_\_\_

STATIC WATER LEVEL (INITIAL) \_\_\_\_\_

{FINAL}

**MEASURING POINT**

CASING I.D. \_\_\_\_\_

**HYDROGEOLOGIST** \_\_\_\_\_

**DRILLER** \_\_\_\_\_

—  
—  
—

**PROJECT NO.** \_\_\_\_\_

DATE(S) INSTALLED \_\_\_\_\_

DATE(S) DEVELOPED \_\_\_\_\_

PUMP (TYPE) \_\_\_\_\_

CAPACITY \_\_\_\_\_

BAILER (TYPE) \_\_\_\_\_

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#### WELL DEVELOPMENT DATA

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**FIGURE 4-5**

Well development will be initiated at least 48 hours and not longer than 7 days after the grout is poured around the well. Well development data will be recorded on the form shown in Figure 4-5. A bailer or pump will be used to develop the well. Water and sediment will be evacuated from the well during development and a swab or the bailer may be used to agitate the water column within the screened interval. The agitation displaces fine material in the well screen and filter pack and allows the material to be removed by additional bailing.

A minimum of five well volumes of water will be removed during development. A volume includes the water standing in the well casing and the saturated annular. Well volume will be calculated using the following formula:

$$WV = (7.48\pi/4) \times [CD^2 + P(BD^2 - CD^2)] \times (WD - GW)$$

where: WV = Well volume (gallons)  
BD = Borehole diameter (ft)  
CD = Casing diameter (ft)  
WD = Well depth  
GW = Depth to groundwater (ft)  
P = Porosity of filter pack

Water levels and well depths will be measured with an electric sounding device. Before development, and at regular intervals during development, measurements of specific conductance, pH, and temperature will be made. Wells will be developed until the water produced is clean to the unaided eye, the water quality parameters have stabilized, and a minimum of five volumes have been removed.

#### **4.4.3 Collection of Groundwater Samples**

Groundwater sampling will be conducted at least 14 days after well development has been completed. Information collected during sampling will be recorded on a Water Quality Sampling form (Figure 4-6). All sampling equipment will be decontaminated before its use in each well as described in Section 4.6.2.

Plastic sheeting will be placed on the ground surrounding the well to prevent contamination of downhole equipment. The water level and total depth of the well will be measured using an electric sounding device, and the height of well casing above ground surface will be measured.

The volume of water standing in the well and the saturated annular will then be calculated as shown in Section 4.4.2. At least five volumes of water will be evacuated from the well using a pump or bailer to ensure that formation water is being sampled. Wells will be purged until the pH, specific conductance, and temperature have stabilized and the required five volumes of water have been removed. Water will be evacuated starting at the

PROJECT \_\_\_\_\_ SAMPLERS \_\_\_\_\_  
PROJECT NUMBER \_\_\_\_\_  
WELL NO. \_\_\_\_\_ SUPERVISOR \_\_\_\_\_  
DATE SAMPLED \_\_\_\_\_ TIME SAMPLED \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

MEASURING POINT \_\_\_\_\_ WELL-DIAMETER (ID) \_\_\_\_\_  
WATER LEVEL \_\_\_\_\_ DATE \_\_\_\_\_ TIME \_\_\_\_\_ WELL DEPTH \_\_\_\_\_  
SCREENED INTERVAL \_\_\_\_\_ SINGLE WELL VOLUME (Gallons) \_\_\_\_\_  
PURGE PUMPING RATE \_\_\_\_\_ PURGE VOLUME (Gallons) \_\_\_\_\_  
DEPTH OF SAMPLING \_\_\_\_\_  
SAMPLE PUMPING RATE \_\_\_\_\_ NO. OF SAMPLES \_\_\_\_\_  
NO. OF SAMPLES RELINQUISHED \_\_\_\_\_ TO \_\_\_\_\_ DATE \_\_\_\_\_  
\_\_\_\_\_

FIELD EQUIPMENT  
EMPH METER \_\_\_\_\_ SERIAL NO. \_\_\_\_\_  
EC. METER \_\_\_\_\_ SERIAL NO. \_\_\_\_\_  
PUMP \_\_\_\_\_ SERIAL NO. \_\_\_\_\_  
TUBING TYPE \_\_\_\_\_  
WATER LEVEL METER \_\_\_\_\_ SERIAL NO. \_\_\_\_\_  
FILTER APPARATUS \_\_\_\_\_ FILTERS \_\_\_\_\_  
BAILER \_\_\_\_\_ SIZE \_\_\_\_\_  
\_\_\_\_\_

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**WATER QUALITY FIELD  
SAMPLING DATA SHEET**

PROJECT NO. 8802

FIGURE 4-6

top of the water column so that all standing water is removed. If a well becomes dry before five volumes are removed, sampling will be conducted the following day.

Water quality parameters including pH, temperature and specific conductance will be measured periodically during the evacuation. In addition, the dissolved oxygen concentration will be measured if a pump is used. The measurements will be taken at least once for every volume of water removed.

Groundwater samples will be collected from the wells after purging as soon as a sufficient volume of water is present in the well for the intended analyses. Samples will be obtained using a bottom-filling disposable bailer. Prior to sample collection, bottles will be rinsed 3 times with formation water, except for volatile organic analyses (VOAs). If obtaining sufficient sample volume is difficult, the sample bottles will be single rinsed rather than triple rinsed. After the bottles have been rinsed, a groundwater sample will be collected and dispensed into the appropriate labeled sample bottles. Samples for VOAs will be collected first, with as little agitation as possible to prevent loss of the volatile components. Samples collected for metal analysis will be filtered using a .45 micron filter. A prefilter will be used for heavily silted water.

Immediately following collection of groundwater samples for laboratory analyses, a final sample will be collected and tested for pH, temperature and specific conductance. The results will be recorded in the field logbook.

#### **4.4.4 Surveying**

The inner casing (riser) for the monitoring wells will be surveyed by a licensed surveyor for both horizontal and vertical control, to a degree of accuracy of 0.1 and 0.05 ft, respectively. The Universal Transverse Mercator (UTM) grid coordinate system will be utilized. Map coordinates will be transferred to the USAEC IRDMIS no later than 30 days subsequent to the last well installation.

#### **4.4.5 Aquifer Testing**

Aquifer testing will be performed on each of the five wells installed at the site to determine the hydraulic conductivity, transmissivity, and storage coefficient (if possible) of the aquifer under the BANGF. The aquifer tests will consist of slug tests that will be performed after the wells have been developed and the first round of groundwater sampling has been performed.

The slug tests will be performed in two stages. First, in the "falling head test," a mandrel (a weighted, sealed PVC tube) will be rapidly introduced into the well, below the static water level. This action displaces the water surface upward, after which it gradually equilibrates to its original level. The second stage, or "rising head test," will then be conducted by removing the mandrel, causing a sudden drop, followed by a gradual rise of the water surface. The rate at which the water level in the well returns to its original

(static) level is proportional to the hydraulic conductivity of the aquifer materials. Procedures that will be used to conduct these tests are as follows:

- The static water level in the well will be determined by measuring the depth to water periodically for several minutes and taking the average of the readings
- An "instantaneous" change in the volume of water in the well will be created by quickly introducing the weighted, sealed PVC tube into the water column.
- The depth to water will be recorded from the top of the well casing using a pressure transducer connected to a data logger or an electronic depth sounder with a weighted tape. Depth to water measurements will be recorded to the nearest 0.01 foot.
- A watch or other timing devise will be used to document the intervals between water-level measurements. The depth to water will initially be measured on an instantaneous basis and then reduced to an interval of 5 to 10 seconds or more for the remainder of the test period.
- The falling head test will be conducted until a minimum of 90 percent of the excess head has dissipated.
- Upon completion of the falling head test, the PVC tube will be quickly removed from the well. The depth to water will be recorded using the procedures described above until a minimum of 90 percent of the head has recovered to the original level.
- The depth to water measurements will be plotted with respect to time. This information will be used to determine the hydrogeologic character of the aquifer.

The data will be analyzed by the Bouwer and Rice Method (Bouwer and Rice, 1976); this method is based upon the Theim equation for steady state flow to a well. The analysis involves a plot of residual head (logarithmic scale) versus time (arithmetic scale). A straight line is applied to the early-time data and used to calculate a value for hydraulic conductivity. The equation to determine the hydraulic conductivity using the Bouwer and Rice Method is as follows:

$$K = \frac{r_c^2 \ln(R_e/r_w)}{2d} \frac{1}{t} \ln \frac{h_o}{h_t}$$

where:  $r_c$  = radius of the unscreened part of the well where the head is rising  
 $r_w$  = horizontal distance from well center to undisturbed aquifer  
 $R_e$  = radial distance over which the difference in head,  $h_t$ , is dissipated in the flow system of the aquifer  
 $d$  = length of the well screen or open section of the well  
 $h_o$  = head in the well at time  $t_0 = 0$   
 $h_t$  = head in the well at time  $t > t_0$

## **4.5 UNDERGROUND COMPLEX SAMPLING**

Sampling activities within the underground complex will include the collection of standing water samples from each of the missile and antenna silos, the tunnel junction rooms, and beneath the floor in the powerhouse. In addition, samples of any product remaining in the 5,000-gallon diesel tank, the two tanks which are part of the demineralizing system, the RP-1 propellant tank, and the two water-storage tanks will also be collected. The following sections discuss the procedures that will be used to collect samples within the underground complex.

### **4.5.1 Standing Water Sampling**

Where possible, standing water samples from the tunnel junction rooms and beneath the powerhouse floor will be collected by holding an appropriate sample container beneath the surface of the water. The containers will be rinsed three times with the standing water, except for the VOAs. For samples requiring chemical preservation, the preservative will be added after the sample bottle is filled.

If the standing water cannot be reached by hand, samples will be collected using a Teflon or stainless steel cup attached to an extension rod. Sampling containers, with the exception of VOAs, will again be rinsed three times with the standing water before a sample is collected for chemical analysis. The samples will then be transferred from the cup to the appropriate labeled bottles. Samples collected for metals analysis will be filtered using a .45 micron filter. A prefilter will be used for heavily silted water.

Samples of the standing water remaining in the missile and antenna silos will be collected using disposable, bottom-filling bailers. The bailer will be lowered to the surface of the water using a braided nylon rope. The bailer will be lowered into, and removed from the water slowly to minimize agitation of the sample. Sample containers, with the exception of the VOAs, will be rinsed three times with water from the sampling location. A sample will then be collected and dispensed into appropriate labeled containers.

### **4.5.2 Tank Sampling**

If possible, tank samples will be dispensed directly from the tank outlet into appropriate sampling containers. However, based on observations made during the RI/FS facility inspection (Stollar & Associates, et al., 1991), five of the six tanks remaining in the complex will have to be sampled through inlet ports. If this is the case, the tanks will be accessed by carefully removing the bolts holding the inlet flanges to the tanks. The flange will then be removed and Teflon lined polyethylene tubing will be lowered to the bottom of the tank. Samples will be siphoned from the tank using a hand operated pump attached to the tubing.

The 5,000-gallon diesel fuel tank will be sampled through an opening located approximately 5 ft from the bottom of the tank, while the RP-1 propellant tank will be sampled through one of several 4-inch flanges that were observed during the facility inspection.

Access to the water storage tanks will be achieved by removing the 4-inch bolted flanges located on the top of each tank. The tank in the air-filtration facility will be accessed by carefully disconnecting the line marked "UA" from the tank. Samples of any liquid remaining in these tanks will be siphoned out, placed in a Teflon or stainless steel cup, visually inspected, and screened for volatile organic vapor using an OVA. The pH and conductivity of the liquid will also be measured using field instruments. If field screening indicates that the liquid may not be clean water, a sample for chemical analysis will be siphoned from the tank and dispensed into appropriate sample containers.

The demineralizing system tanks will be accessed by removing lines leading to the tanks and siphoning liquid from the inlet ports. Samples of any liquid remaining in these tanks will be placed in Teflon or stainless steel cups and screened using pH paper. Barium chloride will be added to the samples for identification of sulfuric acid, and silver nitrate will be add for identification of hydrochloric acid. If field screening techniques fail to positively identify the liquids, samples for chemical analysis will be siphoned from the tank and dispensed into appropriate sample containers.

## **4.6 DECONTAMINATION PROCEDURES**

Decontamination of both personnel and equipment will be necessary during the BANGF SI field investigation to minimize personnel exposure to hazardous materials and reduce the risk of cross contamination between drilling and sampling locations. The following sections provide the procedures that will be used for personnel and equipment decontamination.

### **4.6.1 Personnel Decontamination**

Personnel involved in the field investigation at the BANGF may become contaminated in several ways, including being splashed with liquid chemical products or contaminated water while drilling, developing, testing, and sampling wells and standing water; handling chemical wastes, contaminated soil or water, or contaminated equipment; walking on contaminated soil or through contaminated surface water; and contact with chemical vapors, dusts, fumes, and mists. Decontamination reduces dermal exposure time and prevents hazardous materials from being transferred from protective clothing to the wearer and to clean areas where unprotected individuals can be exposed.

A contamination reduction zone (CRZ) will be established outside the "hotline" where personnel routinely enter and exit the exclusion zone. Standard EPA protocol for the sequential removal of personal protective equipment (PPE) will be followed by field personnel in the CRZ. Boot covers and outer gloves will be washed, rinsed, and removed first; followed by protective suits and safety boots. Inner gloves will then be removed and air purifying respirators will be removed last. All protective clothing will be removed in an

"inside out" manner. Removal of contaminants from clothing and equipment by blowing, shaking, or other means that may disperse material into the air will be prohibited. At the conclusion of work, all protective clothing will be placed in plastic bags before disposal or transfer offsite.

Personnel will not be permitted to exit the CRZ until all contaminated clothing and equipment have been removed and the individuals have washed their hands and faces with soap and water.

#### **4.6.2 Equipment Decontamination**

Drilling equipment (i.e., drill rig, tools, bits, etc.) and well purging equipment (except submersible pumps) will be decontaminated by steam washing the equipment with a laboratory-grade, nonphosphorous detergent (i.e., Alconox) solution and rinsing materials with water from a USAEC-approved source. Drilling equipment will be decontaminated between drilling locations at a designated area of the site constructed to contain the decontamination water. Decontaminated equipment will be wrapped in plastic for transport to the next drilling location to prevent contamination of the equipment and materials. If submersible pumps are used at the site, they will be decontaminated by circulating an Alconox solution through the pump and tubing, followed by a rinse with water from a USAEC-approved source.

Sampling equipment (e.g., bailers, split-spoon samplers, hand augers) coming into direct contact with the sampling media will be decontaminated using the following procedure:

- Remove loose soil and sediment with bristle brushes
- Scrub equipment with a laboratory-grade detergent (i.e., Alconox, Liquinox) solution using brushes
- Rinse equipment with water from a USAEC-approved source
- Rinse equipment with distilled water, air dry, and wrap in plastic sheeting.

Decontamination rinsate from soil sampling activities will be collected and containerized pending the results of chemical analyses at the site. CKY will assist the USAEC with waste packaging, determination of waste characteristics, preparing manifests, and transfer and disposal of investigation-derived waste (IDW).

### **4.7 FIELD EQUIPMENT**

Procedures described in this section pertain to the calibration of equipment and instrumentation that will be used during the BANGF SI field investigation. All field equipment will be calibrated with sufficient frequency and in such a manner that accuracy and reproducibility of results are consistent with the manufacturer's specifications. All calibrations for field equipment will be recorded in appropriate log books and/or forms.

Field instruments which will require calibration include instruments for measuring water levels, headspace analysis, pH, conductivity, and temperature.

#### **4.7.1 Water-level Measurements**

The following are calibration methods that may be applied for various water-level measuring devices which may be utilized for this project:

- Electrical probe calibration: Check against steel surveyor's tape prior to use;
- Graduated steel tape calibration: Manufacturer-supplied temperature correction will be applied if applicable for field conditions; and
- Pressure transducer calibration: Factory calibrated once, field calibration check with water columns prior to permeability or aquifer tests, and periodic field checks against steel tape or electrical probe during long-term monitoring or testing.

#### **4.7.2 Headspace Analysis and Health and Safety Monitoring Instrumentation**

OVA used for headspace analysis will be calibrated daily to methane before field use, as specified by the manufacturer. Photoionization Detectors (PIDs) will be calibrated daily to isobutylene prior to field use, as specified by the manufacturer.

#### **4.7.3 pH Measurement**

Digital pH meter calibration: Calibration checked before each field use. Laboratory-supplied buffer solutions will be renewed daily in the field, and used periodically between measurements. Temperature corrections will be applied during measurement.

#### **4.7.4 Electrical Conductivity**

Electrical conductivity meter calibration: Calibrated before each field use. Temperature correction may be applied automatically by instrument during measurement.

#### **4.7.5 Water Temperature**

Mercury thermometer calibration: Factory calibrated once against U.S. Bureau Standards, and checked at least annually.

Temperature meter calibration: Calibrated weekly against mercury thermometer.

Suggested calibration procedures and precision requirements for field measurement are summarized in Table 4-2.

**Table 4-2 Summary of Field Monitoring Equipment  
Calibration Procedures and Frequencies**

Equipment	Use	Calibration Procedures	Unit of Measure
Organic Vapor Analyzer	Air Monitoring during field investigation for presence of organic vapors. Headspace analysis.	Calibrate daily using 100 ppm methane calibration gas.	Parts per million
Microtip PID	Air Monitoring during field investigation for presence of organic vapors. Headspace analysis.	Calibrate daily using 100 ppm isobutylene calibration gas.	Parts per million
Electrical Probe	Water level measurement.	Check against steel surveyor's tape before use.	Feet
Steel Surveyor's Tape	Water level measurement.	Check against new steel surveyor's tape before use.	Feet
Pressure Transducer	Water level measurement.	Periodically check against steel surveyor's tape or electrical probe.	Feet
pH Meter	Measure groundwater pH during purging and sampling of monitoring wells.	Calibrate before each use with laboratory-supplied buffer solution.	Standard units
Electrical Conductivity Meter	Measure groundwater electrical conductivity during purging and sampling of monitoring wells.	Calibrate daily using conductivity calibration solution (potassium chloride, water, and 0.002 percent iodine).	Micromhos per centimeter
Mercury Thermometer	Measure groundwater temperature during purging and sampling of monitoring wells.	Factory calibrated against U.S. Bureau Standards. Check annually against NIST-certified thermometer.	Degrees Celsius
Temperature Meter	Measure groundwater temperature during purging and sampling of monitoring wells.	Calibrated weekly against a mercury thermometer.	Degrees Celsius
Oxygen Meter	Measure oxygen content of the air in the underground complex during sampling activities.	Calibrated bimonthly with ambient air	% O <sup>2</sup> by Volume
Hydrogen Sulfide Meter	Evaluation of the atmosphere in the underground complex.	Calibrated bimonthly with 90 ppm H <sub>2</sub> S	Parts per million
Combustible Gas Indicator	Used to monitor potential explosive atmospheres during sampling activities in the underground complex.	Calibrated bimonthly with standard calibration gas (30% methane).	% LEL

## **5.0 SAMPLE HANDLING AND ANALYSIS**

This section summarizes the sample containerization, preservation, labeling, and tracking procedures that will be used during the BANGF sampling activities.

### **5.1 SAMPLE CONTAINERS**

To ensure the integrity of aqueous and soil samples, steps will be taken to minimize contamination from the containers in which they are stored. For aqueous samples, if the analyte(s) to be determined are organic in nature, the container will be made of amber glass. If the analyte(s) are inorganic, the container will be polyethylene. When both organic and inorganic substances are expected to be present, separate samples will be taken. Stainless steel sleeves (tubes) will be used to contain soil samples for both organic and metal analysis. New sample bottles and tubes will be used for each sample.

Aqueous and soil samples will be collected in the following containers as listed on Table 5-1.

#### **5.1.1 Precleaned Sample Containers**

Precleaned sample containers will be supplied by the laboratory. The laboratory will purchase precleaned containers from a laboratory supplier. The supplier will preclean the container as follows:

##### **5.1.1.1 Amber Glass Bottles and Wide-Mouth, Clear Glass Jars**

1. Wash the containers, closures, and Teflon liners in hot tap water with a laboratory grade non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse one time with a 1:1 mixture of nitric acid and deionized water.
4. Rinse three times with ASTM Type I deionized water.
5. Rinse one time with pesticide-grade methylene chloride.
6. Oven dry containers, closures, and liners.
7. Remove containers, closures, and Teflon liners from oven.
8. Place Teflon liners in closures and place closures on container. Attendant will wear gloves and the containers will not be removed from the preparation room until sealed.

Table 5-1 Sample Containers

Parameter	Water	Soil
1. Volatile Organic Compounds	Amber glass VOA vials w/Teflon septum	Sampler Tube or 8 oz wide mouth glass jars
2. Semivolatile Organic Compounds	Amber glass w/Teflon cap	Sampler Tube or 8 oz wide mouth glass jars
3. Metals	Polyethylene bottle w/Teflon cap	Sampler Tube or 8 oz wide mouth glass jars
4. Anions	Polyethylene bottle w/Teflon cap	Sampler Tube or 8 oz wide mouth glass jars
5. Total Petroleum Hydrocarbons	Amber glass w/Teflon cap	Sampler Tube or 8 oz wide mouth glass jars
6. Gross Alpha/Beta	Plastic Cubitainer	-----
7. Polychlorinated Biphenyls (PCBs)	-----	Sampler Tube or 8 oz wide mouth glass jars

#### **5.1.1.2 40 ml Borosilicate Glass Vials**

1. Wash the containers, septa or liners, closures in hot tap water with a laboratory-grade non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse three times with ASTM Type I deionized water.
4. Oven dry containers, septa or liners, and closures.
5. Remove containers, septa or liners, and closures from the oven.
6. Place liners in closures, Teflon side down, and place closures on containers. Attendant will wear gloves and the containers will not be removed from the preparation room until sealed.

#### **5.1.1.3 Polyethylene Bottles**

1. Wash the containers, closure, and Teflon liners in hot tap water with a laboratory-grade, non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse one time with a 1:1 mixture of nitric acid and deionized water.
4. Rinse three times with ASTM Type I deionized water.
5. Air dry in contaminant-free environment.
6. Place liners in closures and place closures on containers. Attendant will wear gloves and the containers will not be removed from preparation room until sealed.

## **5.2 SAMPLE PRESERVATION**

It is important to maintain the integrity of the samples from the time of collection until the analyses are performed. Following sample collection, the sample will be preserved using the preservation techniques and procedures recommended by the EPA (see Table 5-2).

Sample preservation will be performed in the field by a qualified technician trained in the preservation techniques for inorganic and organic compounds.

**Table 5-2 Sample Holding Times and Preservatives**

Parameter	Preservative		Analytical Method	Maximum Holding Times
	Water	Soil		
<b>Metals</b>				
-Al	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Sb	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Ba	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Be	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Cd	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Ca	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Cr	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Co	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Cu	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Fe	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Mg	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Na	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-K	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Mn	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Mo	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Ni	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Ag	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Ti	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Vi	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-Zn	HNO <sub>3</sub> to pH < 2	Cool to 4°C	ICP	180 days
-As	HNO <sub>3</sub> to pH < 2	Cool to 4°C	GFAA	180 days
-Se	HNO <sub>3</sub> to pH < 2	Cool to 4°C	GFAA	180 days
-Pb	HNO <sub>3</sub> to pH < 2	Cool to 4°C	GFAA	180 days
-Hg	HNO <sub>3</sub> to pH < 2	Cool to 4°C	CVAA	28 days
-PCBs	----	Cool to 4°C	GC/EC	7 days until extraction 40 days after extraction
Volatile Organic Compounds	Cool to 4°C	Cool to 4°C	GC/MS	14 days until extraction
Semivolatile Organic Compounds	Cool to 4°C	Cool to 4°C	GC/MS	7 days until extraction 40 days after extraction
Total Petroleum Hydrocarbons	Cool to 4°C HCL to pH < 2	Cool to 4°C	IR	7 days until extraction 30 days after extraction
Gross Alpha/Beta	HNO <sub>3</sub> to pH < 2	-----	Gas Flow Proportional Counting	180 days

ICP - Inductively Coupled Plasma

GFAA - Graphite Furnace Atomic Absorption

CVAA - Cold Vapor Atomic Absorption

GC - Gas Chromatography

EC - Electron Capture

MS - Mass Spectrometry

IC = IR - Infrared Spectrophotometer

### **5.3 SAMPLE HOLDING**

The time that a preserved sample may be held between sampling and analysis is based on the stability of the analyte(s) of interest. Holding time limitations are intended to minimize chemical change in a sample before it is analyzed. Results reported for samples extracted or analyzed after holding times have been exceeded will be considered out of control and unacceptable. To expedite analysis and to minimize the possibility of exceeding holding times, samples must be sent to the laboratory by a fast, reliable method as soon as possible after collection. Table 5-2 summarizes allowable holding times for each analysis and sample matrix. In general, all samples shipped from the field will be maintained at 4°C and retained in the laboratory at 4°C.

### **5.4 SAMPLE LABELING**

An adhesive, waterproof sample label will be affixed to each individual sample collected. The following information will be recorded with a waterproof marker on each label.

- Project name and location;
- Project number;
- Unique chronological sample identification number;
- Sample location and depth;
- Sample type;
- Date and time of collection;
- Sampler's initials;
- Analyses to be performed on the sample; and
- Sample preservation (if any).

### **5.5 SAMPLE SHIPMENT**

The following discussion outlines generic procedures for shipment of samples.

- A member of the field team will be designated Sample Coordinator. The Sample Coordinator will place the sample in a plastic ice chest with ice packs and suitable packing material. The original chain-of-custody (COC) form will be signed, dated, and the time recorded by the Sample Coordinator prior to transferring custody for shipment. Figure 5-1 shows a copy of the COC form. A notation will be made in the remarks section of the record indicating method of shipment, courier's name, and other pertinent information.



The COC will be sealed in an envelope and a custody seal will be placed on the envelope flap. The envelope will be taped to the inside of the ice chest with the name and address of the receiving laboratory prominently displayed. The ice chest will be taken directly to the shipping agent by the Sample Coordinator and custody relinquished to the shipping agent.

- The Sample Coordinator will close and seal the ice chest with a custody seal. The Sample Coordinator will fill out the custody seal as described above with the exception that the sample number will not be necessary when several samples are placed in each ice chest. The seal will be attached to the ice chest in such a way that it will be necessary to break it to open the ice chest. All custody seal must be applied to sample containers and ice chests by the Sample Coordinator. The ice chest will be taped closed by wrapping each end at least twice with either fiberglass-reinforced tape or a strong adhesive tape. Paper tape or "Scotch" tape will not be allowed.
- The Sample Coordinator will inform the laboratory by telephone that the samples have been shipped and will arrive during working hours the following day.

## **6.0 INVESTIGATION-DERIVED WASTE**

IDW that will be generated during the BANGF SI field investigation include drill cuttings, purge water from groundwater monitoring wells, decontamination water, and used protective clothing. The following sections discuss the procedures that will be used for the containerization, characterization, and disposal of each type of IDW.

### **6.1 DRILL CUTTINGS**

During drilling and hand augering activities at the BANGF, drill cuttings will be screened for the presence of organic vapors using an OVA. Soil IDW generated during drilling and hand augering activities will be containerized in 55-gallon drums pending results of laboratory analyses of samples collected from the borings at each location.

If analytical results indicate potential contamination, several grab samples will be collected from the drums containing the relatively elevated laboratory results. The samples will be composited and analyzed for toxicity characteristic leaching procedure (TCLP) of contaminants of concern. If TCLP concentrations exceed regulatory limits, CKY will arrange for the soil to be disposed in an appropriate landfill by a licensed hazardous waste hauler (West Hazmat Contracting, Inc.). If TCLP concentrations are under regulatory limits, but the soil contains TPH concentrations greater than 50 parts per million (ppm), metal concentrations greater than background, or any detected concentrations of chemicals that are not naturally occurring (i.e., VOCs and SVOCs), the soil IDW will be considered a solid waste and will be managed as such. If concentrations are less than the levels of TPH, metals, and unnaturally occurring chemicals listed above, the IDW will be considered "clean fill" and will be spread at the site.

### **6.2 PURGE WATER**

Water IDW will be generated during the development and pre-sampling purging of the five perimeter monitoring wells that will be installed at the BANGF. The water IDW will be containerized in 55-gallon drums at each well location pending laboratory results. If analytical results of groundwater samples indicate potential contamination, samples of the water IDW will be collected and analyzed for TCLP contaminants of concern. If TCLP concentrations are under regulatory limits, the water will be disposed on site. If TCLP concentrations exceed regulatory limits, CKY will arrange for the disposal of the IDW at an appropriate facility by a licensed hazardous waste hauler (West Hazmat Contracting, Inc.).

### **6.3 DECONTAMINATION WASTES**

Liquid IDW generated by steam cleaning and decontamination of drilling and sampling equipment will be containerized in 55-gallon drums on a daily basis. Samples will be collected from the drums after the sampling program is complete and analyzed for TCLP VOCs, TCLP SVOCs, and TCLP metals. If the TCLP concentrations are under regulatory limits, the water will be disposed on site. If TCLP concentrations exceed regulatory limits, CKY will arrange for the disposal of the IDW at an appropriate facility by a licensed hazardous waste hauler (West Hazmat Contracting, Inc.).

### **6.4 MISCELLANEOUS SOLID IDW**

Miscellaneous solid IDW (i.e., protective coveralls, nitrile gloves, tubing, etc.) generated during the BANGF SI field effort will be containerized in plastic bags, labeled, dated, and moved to a designated location at the site pending analytical results. The disposal of this IDW will depend on the soil, water, and/or TCLP analytical results of the locations where it was generated. If analytical results are below regulatory levels, the IDW will be disposed in a sanitary landfill. If the analytical results are greater than regulatory levels, CKY will arrange for the IDW to be transported and disposed at an appropriate facility. PPE that comes into contact with the standing water in the underground complex will be considered contaminated with asbestos. This IDW will be disposed in accordance with all applicable state and federal requirements.

## **7.0 REPORTING AND SCHEDULE**

### **7.1 REPORTING**

All information collected during the BANGF SI field investigation will be consolidated, summarized, and included in the reporting documentation. Field data related to the drilling and sampling of soil borings, installation and sampling of monitoring wells, and sampling of tanks and standing water within the underground complex will be reviewed. Any inaccuracies or discrepancies will be resolved by the project team prior to laboratory analysis and data validation. After the laboratory analyses are completed and the chemical data are validated, the data will be evaluated to determine the presence and type of contamination, if any, at the specific sampling locations. The data will also be used to determine if additional investigations are warranted at the site.

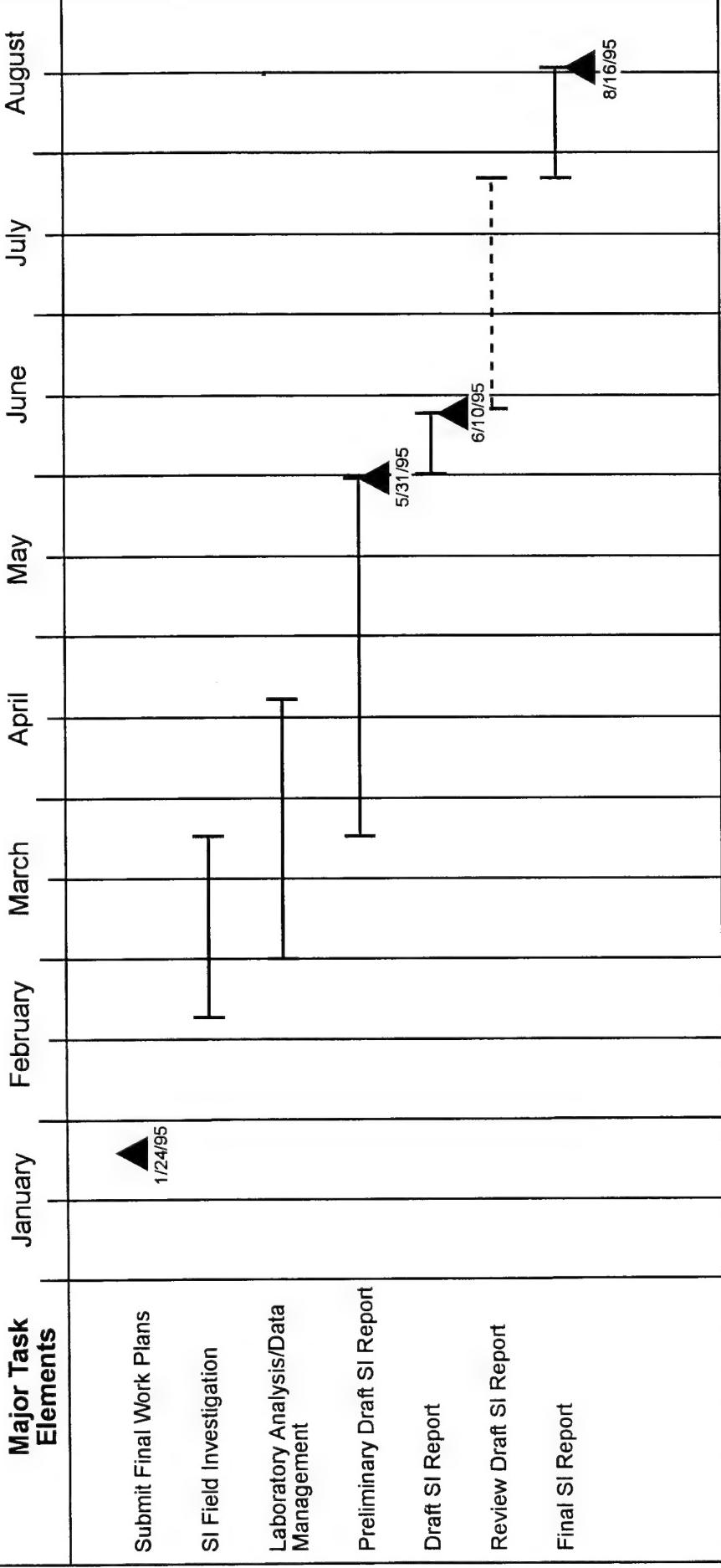
A SI report will be prepared following conclusion of the field activities and receipt of all analytical data. The report will summarize what is known about the site, the activities conducted during the SI, results of the field investigation, and recommendations for further action, if required. In addition, the SI report will include a separate section to fulfill any omissions identified from the PA Review Checklist.

Two versions of the report will be prepared and submitted to the USAEC; draft and final SI reports. Prior to the submission of the draft report, 10 preliminary copies of the draft report will be submitted to USAEC for review. The draft report will incorporate any alterations required by the preliminary review. The USAEC will distribute the draft report to the appropriate regulatory agencies for review. Upon receipt of the regulatory agency comments, a comments response package will be prepared. This package will include the final SI report that includes all alterations resulting from the draft review and a narrative describing how each comment was addressed in the final SI report.

### **7.2 SCHEDULE**

The schedule presented in Figure 7-1 gives an approximate timetable and major milestones for the SI, including conducting the field investigation and submitting the SI report. This schedule is based upon notice to proceed (NTP) for the SI field investigation. NTP will occur after USAEC and regulatory approval of the SI work plan package.

### Schedule for Completion



### EXPLANATION

- CKY Activity
- USAEC and Regulatory Review
- Deliverable Due

**CKY** CKY incorporated  
Environmental Services

**ESTIMATED SCHEDULE**

PROJECT NO. 8802

FIGURE 7-1

## **8.0 REFERENCES**

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**APPENDIX A**

**INSPECTION NOTES**

Inspection Notes  
Bennett Army National Guard Facility

September 17, 1990

Personnel:	Elizabeth Sopher Brian Myller	R.L. Stollar and Associates
	Richard Urie Joan Henehan Dave Farler	Urie Environmental Health
	John Zahorchak	All Mobile Crane and Welding

The morning was spent removing two concrete blocks from the entry hatch using a 6.5 ton crane. The crane remained on site throughout the field program to secure the hatch cover open. The hydraulic arm of the hatch has been removed and the cover must be held open. The crew entered the complex in groups of two, with a third person staying in the entry portal area to act as a communications link and as a backup for safety reasons. A tour was made of the entire complex to monitor the atmosphere. The crews used Level B personal protective equipment including self-contained breathing apparatus (SCBA).

September 18, 1990

Personnel:	Elizabeth Sopher Brian Myller	R.L. Stollar and Associates
	Dave Farler Diane Robinson Don Angell	Urie Environmental Health
	John Zahorchak	All Mobile Crane and Welding

All five Stollar and Urie personnel entered the complex to inspect the area in more detail, videotape and collect additional air-monitoring samples. Based on air monitoring conducted on 9/17 personnel wore half-face respirators because of the potential for asbestos exposure. One person carried a self-contained breathing apparatus (SCBA) for backup safety purposes. A description of each area of the complex is provided below.

#### ENTRY HATCH

The complex was accessed through an entrance hatch located adjacent to the entry portal. The hatch is a manhole, approximately 5 ft in diameter and 18 ft in length. At the base of the manhole, are two doorways. The doorway to the west opens into a rectangular chamber containing a metal stairway leading to the surface. Access to this stairway from the surface is blocked with a steel plate which is partially covered with dirt. The doorway on the east, which is partially blocked with a piece of heavy gauge metal, leads to the main entry portal.

#### ENTRY PORTAL

The elevator shaft is present and the car is resting on the bottom level. A stairway around the outside of the elevator shaft leads from the bottom of the manhole down to the complex entrance. The stairway is functional and drops approximately 30 ft in three levels. On the north side of the upper level of the staircase, a doorway to the elevator is missing which leaves an unprotected opening to the elevator shaft. There is graffiti on the walls of the portal and water is present beneath the suspended

floor at the bottom of the shaft. There is some trash (plastic bags, beer cases, wood) around the portal.

#### ENTRANCE TUNNEL

The entry portal leads to the tunnel connecting the powerhouse and the control center. On the north side of the tunnel are two water storage tanks. The tank openings which are visible from this tunnel are flange, approximately 4" in diameter, with a cover bolted in place. No other piping connections are visible on the tanks.

#### POWERHOUSE

The powerhouse is a two level, dome structure located east of the entry portal. The tunnel entrance is on the lower level of the structure. There is metal grate flooring in most areas and there is water beneath the floor. There are many holes in the floor where equipment was removed. In the center of the lower level are the foundations for generators. The generators have been removed. The only equipment remaining in the powerhouse are several storage tanks, portions of a generator and piping.

Three tanks, apparently associated with a water demineralization operation are present at the north end of the power house. One of the remaining tanks, which has approximately 300 gal capacity and is labeled Sulfuric Acid, has a hole in it where the metal has been dissolved to form what appear to be crystalline sulfates. We could not see whether there was more liquid inside the tank. Two other tanks appeared to be in good condition. They are approximately 500 gallon capacity vertical tanks. One was labeled "Acid and \_\_\_\_\_", the last word could not be read. The other tank was labeled "Danger".

At the south end of the main level some generator or boiler parts were laying on the floor. An oily substance, possibly diesel fuel, was splattered on the equipment.

There are stairs on the west side of the powerhouse leading up to the mezzanine level. Air intake and exhaust pipes come up through this level from the generators and lead to the Powerhouse Exhaust Facility.

The Air Filtration Facility is located north of the powerhouse and is connected to the powerhouse by a tunnel on the mezzanine level. In the facility, at the level of the powerhouse mezzanine is a large fan on a suspended concrete floor. To the west, is a two-level room which has dust collecting equipment on the bottom level. The lower level extends beneath the suspended floor. The upper level is empty except for a white tank, which is unlabeled. The tank appears to be in good shape; it is cylindrical and has approximately 500 gallon capacity. Pipes entering the tank (approximately 1") are labeled "UA."

The tunnel leading to the Powerhouse Exhaust is on the south side of the mezzanine level. Exhaust pipes of many sizes from the generators and boilers pass through the tunnel. Most of the pipes are covered with friable white insulating material. Pieces of insulation are lying on the floor and the entrance to the tunnel is covered with crushed insulation. Samples of this material were collected and analyzed. Analysis of this material showed it contained 50 to 75 percent total asbestos.

A 5000-gallon diesel fuel tank is present approximately 20 feet south of the powerhouse on the east side of the tunnel. A round opening, approximately 5 ft from the bottom of the tank is open. 1 to 2 inches of brownish liquid is present in the bottom of the tank.

Further down the tunnel, a large mound of dirt is present at the former location of two 67,000-gallon fuel tanks. The tanks were removed by excavating from the surface and dirt has come into the tunnel through the openings. South of the dirt mound is the exhaust room. There is a loft in the room which contains horizontally oriented piping. Metal plate flooring is present on the sides of the room and an uncovered pipe trench filled with pipe and water is in the center of the room. There is a large fan in the wall at the end of the room.

## CONTROL ROOM

The control room is a two-level dome structure. The structure is almost empty except for one computer console on the second level. On the main level, there are some bed parts in the ready room and a latrine without any fixtures. Black and white tile flooring is present on the second level.

## ANTENNA SILOS

A tunnel, approximately 500 ft long, leads from the entrance tunnel south to the antenna silos. The tunnel contains piping racks, and there is yellow insulating material (fiberglass) on the floor. Pipe elbows are generally insulated with asbestos, rather than the fiberglass used on the rest of the piping.

At the end of the tunnel is a small room with a metal case lying in the middle. There is approximately 3 inches of water on the floor and metal plates are missing from the floor in several areas. In addition, there is several feet of water beneath the floor.

The two silos are identical. There is approximately 3 inches of water on the floor and several feet of water beneath the floor. The stand for the spherical antenna is present. There are cribbing and metal stairs around the perimeter of the silo. Components of the hydraulic system used to open the hatch remain at the top of the silo.

## LAUNCH COMPLEXES

A northerly trending tunnel leads from the entrance tunnel to the launch complexes. The tunnels are damp in some areas and there is insulating material lying on the floor along the length of the tunnels. The white paint is peeling in many areas revealing red primer paint underneath.

Approximately 75 feet north of the entrance is Tunnel Junction 12 which contains the Fuel Terminal. The 40,000 gallon RP-1 fuel tank is at the west end of the room. Disconnected pipes labeled RP-1 are present in several areas. On the south end of the room the tops and fittings of four high pressure nitrogen tanks are visible. A large portion of each of the tanks lies outside the room, only the end of each tank and some connecting pipes are inside.

The next tunnel junction, at the branch to Launch Complex 1, has 1-2 feet of water in it. An escape hatch leads to the surface from the room. At ground surface this hatch is covered with dirt. There are pieces of metal, piping, hoses and other trash lying on the floor in the water. A metal beam, connected to the southern tunnel serves as a bridge, but it does not cross the room completely. The other parts of the room can be accessed by stepping on the trash.

The three identical launch complexes are composed of a Propellant Room, an Equipment Terminal and a silo. Launch Complex 1 is located on the west side of the complex, Launch Complex 2 is on the north and Launch Complex 3 is on the east.

### Launch Complex 1

Propellant Terminal - The only equipment left in the propellant room is the central scaffold and platform. It is attached to the north side of the room at the tunnel leading to the silo. There are approximately 5 ft of water in the room and pipes and other equipment lie under the water.

Silo 1 - We entered the silo from the tunnel on the east, approximately 45 ft below ground surface. There is another tunnel about 10 feet below us on the north side. There is a platform which has several tiers on the north wall of the silo. There are pipes attached to the walls of the silo; all the cradles for the missile have been removed. There is 81 ft of water standing in the silo.

Equipment Terminal - We entered the terminal on the third level from the tunnel on the south side. There are ladders to the upper and lower levels near the tunnel entrance. There is an elevator shaft on the right side as we enter the terminal and an open shaft reaching all four levels in the middle of the terminal. The uppermost level (fourth) contains some air filtration equipment. There is dirt on

the floor from an unknown source between the ladder and the elevator shaft. The third level is empty with some duct and scrap metal lying on the floor. There is a black and white tile floor on this level. The second level contains some air conditioning duct work, the motor for the sewage ejection system and an entrance to a tunnel to the silo. There is red/orange liquid, which may be a result of oxidizing metal, draining down the side of the terminal to the lower level. One of the rubber seals which is at the top of the wall between the elevator shaft and the ladder area is gone, it appears to have been dissolved, possibly by mold. The lowest level contains some metal scaffolding and a large tank with piping labeled "ethylene glycol". There is mold growing in the orange/red water which is beneath the floor plates and there is mold on the surface of the tank.

#### Launch Complex 2

Propellant Terminal - The room looks similar to the one in Launch Complex 1. However, dirt has come into the room through the door to the LOX tank, and there is a large pile of fill on the floor of the room.

Silo - The silo looked similar to the one in Complex 1, and it contained approximately 36 ft of standing water.

Equipment Terminal - The terminal is structured identically to the terminal in complex 1; however, the lowest level is filled with water. There is equipment floating on top of the water. The second level contains air conditioning equipment and the sewage ejection system. There is an oil pan under the air equipment and some oil is spilled on the floor (Less than 1/2 gall). The tunnel to the silo is dry. The third level contains a few computer consoles and there is vermiculite in a trough around the edges of the terminal. The fourth floor is empty and has dirt on the floor in the same location as the Complex 1 terminal.

#### Launch Complex 3

Propellant Terminal - The door is locked and we cannot enter the room.

Silo - The silo was similar to the other silos and it contained 67.5 ft of standing water.

Equipment Terminal - The terminal is similar to the equipment terminal in Launch Complex 2 with water filling the lowest level. Air conducting equipment is present on the second level, the third level is empty and the fourth level contains air filtering equipment. Dirt is present on the floor of the fourth level in the same location in all three of the equipment terminals.

**APPENDIX B**

**ASBESTOS SAMPLING RESULTS**



# HAGER LABORATORIES, INC.

Golden, Colorado 80401  
(303) 278-3400 (800) 878-3434  
FAX # (303) 278-2121

## REPORT ON SERVICE NUMBER 50264AH September 20, 1990

Customer Project Code:

- To: Mr. David Farler  
Urie Environmental Health  
11407 W. I-70 Frontage Rd., N.  
Wheat Ridge, CO 80033
- Analysis: The following samples were submitted for analysis:  
Two bulk samples for asbestos identification and content determination.  
Three membrane filter samples and two blanks for fiber count.
- Method: ASBESTOS (identification)  
Each sample was analyzed following EPA method 600/M4-82-020. Portions of each bulk material were immersed in oil of known refractive index on a microscope slide and observed at 100-125 power using a McCrone Dispersion Staining Objective with polarized light. Characteristics of the fibers under polarized light and dispersion staining conditions were compared to similarly prepared samples of known asbestos types. Optical estimates of the asbestos fiber content were made by comparing the quantity of non-asbestos material to asbestos fibers.
- FIBER (count)  
The fiber concentration of each filter sample was determined following NIOSH Method 7400 (A Rules). Wedges from each filter were examined at 400 power using phase contrast microscopy. All fibers longer than five (5) microns with a length-to-width ratio of 3:1 or more were counted.
- Results: The results are found on Tables 1 - 2.
- Discussion: The present OSHA permissible exposure limit (PEL) for asbestos is 0.2 fibers/cc.  
Detection limit for bulk samples is <1% asbestos fibers.  
LT( ) indicates "less than" with the lower limit of quantification shown in parentheses.  
All filter samples have been corrected for the blank unless otherwise noted.  
The Laboratory has been EPA approved for asbestos analysis since 1979, and is accredited under NIST/NVLAP for asbestos fiber analysis.  
This report relates only to the items tested and may not be reproduced except in full with the approval of the laboratory.  
Hager Laboratories, Inc., has been accredited by the American Industrial Hygiene Association (AIHA) since 1977 and is enrolled in the AIHA Proficiency Analytical Testing (PAT) Program for phase contrast microscopy. Microscopists have completed the NIOSH 582 course "Sampling and Evaluating Airborne Asbestos Dust".

Page Two, SN 50246AH  
Urie Environmental Health  
September 20, 1990

Discussion:      Laboratory data are filed and available upon request. A portion of each sample is retained for subsequent review and future analysis.  
(Cont.)

If you have any questions, please contact our Technical Services Department, at (303)278-3400 or toll free at (800)878-3434.

Filter Samples  
Analyzed by:

*Daniel Fillipi*  
Daniel Fillipi

Date Analyzed: 9-20-90

Bulk Samples  
Analyzed by:

*Sandra L. McCarty*  
Sandra L. McCarty

Date Analyzed: 9-20-90

Submitted by:

*Patricia G. Manning*  
Patricia G. Manning  
Microscopy Supervisor

PGM/slt



TABLE 1

Sample ID	Homogeneous (Y/N)	Sample Color	No. of Layers	Asbestos Present (Y/N)	Chrysotile (%)	Amosite (%)	Crocidolite (%)	Anthophyllite (%)	Thermolite/Actinolite (%)	Total Asbestos (%)	Fibrous Glass (%)	Cellulose Fibers (%)	Other Fibers (Type/%)	Non-Fibrous Material (Type/%)	Sample Description
Powerhouse Floor	Y	grey	1	Y	5-15	30-50				50-75	trace				
Tunnel to Power-house Exhaust	Y	grey	1	Y	15-30	15-30				50-75	trace				

Note: trace = less than or equal to 1%.

N 50264AH  
September 20, 1990

TABLE 2

Sample Number	Counted (fibers)	Counted (fields)	Total (fibers)	Air Volume (liters)	Air Concentration (fibers/cc)
B.9.18.90.1	2.	100.	LT(4900.)	723.	LT(0.007)
B.9.18.90.3	3.	100.	LT(4900.)	751.	LT(0.007)
B.9.18.90.10	3.	100.	LT(4900.)	472.	LT(0.01)
Blank #1	0.	100.	LT(4900.)	-	-
Blank #2	0.	100.	LT(4900.)	-	-

**APPENDIX C**

**CERTIFICATES OF CLEARANCE**

**LOWERY BOMBING RANGE**

CERTIFICATE OF CLEARANCE

All lands within the Lowry Bombing Range, located approximately 21 miles southeast of Lowry Air Force Base, Colorado, described as follows; All of sections 12, 13 and 24, T.58, R.65W; 6th principal (sic) meridian. All of the above land located in Arapahoe County, Colorado; Department of Interior land, 1920 acres. Above land description was obtained from and prepared by Air Installation Engineers, Real Estate Division, Lowry Air Force Base, Colorado.

All of the above described land has been given a careful visual search and has been cleared of all dangerous and/or explosive materials reasonably possible to detect. There are no restrictions on the future use of all land in section 24. It is recommended that all land in sections 12 and 13 be restricted to surface use only. It is possible that subsurface ordnance remains undetected in sections 12 and 13 due to prior usage as impact area and heavy growth of vegetation. All present and/or future owners and/or inhabitants of these lands are hereby advised that if at any time an item identified or suspicious of being military ordnance is located, the nearest government or civil authorities should be notified immediately.

Date of this clearance was 21 October 1959.

/s/ Gayle K. Braesicke  
GAYLE K. BRAESICKE  
1st Lt. USAF

COPY

11 May 1963  
(Decontaminated May 1963) filed in Lot 2,  
Lowry AFB, AF Facility S-7, C2-3-9551

S E C T I O N I  
C E R T I F I C A T E O F C L E A R A N C E

UNRESTRICTED FOR ANY FUTURE USE

6 June 1963

All lands (approximately 54,466.16 acres more or less) within Lowry Missile Site Nr. 1, located approximately 14 miles Southeast of Lowry Air Force Base, Colorado, Townships 4 and 5 South, Ranges 63, 64 and 65 West of the 6th Principal Meridian and described as follows have been thoroughly searched and are cleared of all explosive ordnance and ordnance residue reasonably possible to detect:

"A tract of land lying within the military reservation of Lowry AFB Bombing Range (currently known as Lowry Missile Site Nr. 1), being all of Sections 31, 32, 33, 34, 35 and 36 of Township 4 South, Range 65 West; all of Sections 1, 2, 3, 4, and Section 5 less Complex 1-A, Section 6, Section 8 less Ammunition Storage Area, Sections 9, 10, 11, 12, 13, 14, 15, 16, and Section 17 less Demolition Area, East  $\frac{1}{2}$  of Section 20, Sections 21, 22, 23, 24, 25, 26, 27, 28, 33, 34, 35 and 36 of Township 5 South, Range 65 West; all of Sections 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 and Sections 25 and 36 less Complex 1-C of Township 4 South, Range 64 West; all of Sections 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36 and Section 20 less Complex 1-B of Township 5 South, Range 64 West; all of Section 31 of Township 4 South, Range 63 West; all of Sections 6, 7, 17, 18, 19, 20, 30, 31, West half of Sections 5 and 8, and Section 29 less Complex 2-A of Township 5 South, Range 63 West of the 6th Principal Meridian, Arapahoe County, Colorado. As official plot by the Bureau of Land Management and filed and recorded at the Arapahoe County Seat, Littleton, Colorado." (Description was obtained from Real Property Officer, Civil Engineering Division, Lowry AFB, Colorado.)

Attached map (LF 7-21) reflects the areas decontaminated.

There are no restrictions on the future use of all the above described lands.

Because of surface distortion caused by previous use of the lands, all present and/or future users, owners and/or inhabitants of these lands are hereby advised that if, at any time, an item identified or suspected of being military ordnance is located, the nearest government or civil authority should be contacted.

Date of clearance was 24 May 1963.

Durward G. Price  
DURWARD G. PRICE  
Captain, USAF  
Range Clearance Project Officer

1 Atch  
Map a/s

S E C T I O N II

**REPORT OF CLEARANCE**

6 June 1963

### 1. References and Authority:

- a. Ltr, 2701st EOD Sq, 25 Sep 62, Range Survey Report- Lowry Missile Site Nr. 1, w/l4 indorsements thereto.
  - b. Ltr, ATC (ATEOM-OR), 20 Feb 63, Notice of Contamination - Declaration of Excess Lowry Missile Site Nr. 1, w/lst Ind, AFLC (MCEFR-1), thereto.

2. Range Description: A tract of land located within the Lowry Missile Site Nr. 1 (formerly known as Lowry AFB Bombing Range) approximately 1½ miles Southeast of Lowry Air Force Base, Colorado. Controlling installation is Lowry Air Force Base, Colorado.

3. Range Area: Approximately 54,466.16 acres.

Date Project Started: 1 May 1963      Completed: 24 May 1963

5. Number of Personnel Utilized: 2 Officers and 18 Enlisted Men.

**6. Manhours Utilized:**

a. In Decontamination: 2,265

In Travel Time to and from Range: 311

To Mutual Time to and from Home Station: 690

Total: 3,266

### 7. Total Cost of Clearance:

a. POL Costs:

(1) Gasoline- 2,531.5 gals @ \$ .14 gal = \$354.40

(2) Motor Oil - 25 gals @ \$1.92 gal - 28.00

(3) Fuel Oil - 70 $\frac{1}{4}$  gals @ \$ .10 gal - 70.40

Total: \$452.80

### b. Demolition Material Costs:

(1) Comp C-1 case @ \$29.00 case - \$29.00

(e) Safety Edge- 100 ft  $\pm$  .01 ft = 1.00

(3) Blasting Caps- 20 ea @ \$ .04 ea - .80

(4) Fuse Lighters- 25 ea @ \$ .34 ea - 8.50

Total: \$39.30

c. Vehicle Maintenance: \$109.45

d. Transportation and Per Diem Costs:

(1) Transportation- \$ 673.75

(2) Per Diem- 1528.29

Total: \$2202.04

e. H-21 Helicopter provided by Lowry AFB for  
4 hours @ \$250.00 per hour - \$1000.00

Total Costs: \$3803.59

f. Cost Per Acre: \$.07

8. Hazardous Material Recovered and Disposition:

a. Powder, Paraflare - 5 lbs - Burned

b. Motor, Rocket 2.75" - 28 ea - Burned

c. Head, HE Rocket 2.75" - 11 ea - Detonated

d. Cartridge, Photoflash - 110 ea - Detonated

e. Grenade, Smoke - 1 ea - Burned

f. Igniter, WP - 2 ea - Detonated

g. Head, HE Rocket 5" - 1 ea - Detonated

h. Fuze, Rocket, Mk 149 - 1 ea - Detonated

i. Charge, Spotting, MLAl - 1 $\frac{1}{4}$  ea - Detonated

j. Igniter, WP M23 - 2 ea - Detonated

k. Fuze, Mech Time, ML52 - 2 ea - Detonated

l. Fuze, Mech Time, T 73 - 8 ea - Detonated

m. Bomb, Practice, Mk 23 w/spot. Charge 17 ea - Detonated

n. JATO 15KS1000 -	1 ea -	Burned
o. Bomb, Incendiary, M69 -	1 ea -	Burned
p. Bomb, Incendiary, M74 -	2 ea -	Burned
q. Projectile, 20 MM, HE -	350 ea -	Detonated

9. Inert Material Recovered and Disposition: Light Ferrous Metal, 30,000 lbs, turned in to Marketing and Redistribution Activity, Lowry AFB, Colorado.

10. Vehicles and Equipment Used and Adequacy:

a. Truck, Cargo, 6 x 6, 2½ ton -	3 ea
b. Truck, Cargo, 4-dr, 4 x 4 -	2 ea
c. Truck, Dump, 5 ton -	2 ea
d. Truck, P/U, ½ ton -	1 ea
e. Tractor Bulldozer D-6 -	1 ea
f. Disc 12' w/24" Blades -	1 ea

Vehicles and equipment were considered adequate.

11. Difficulties Encountered:

a. Manpower Losses: 95 m/hrs were lost because of sick call and minor injuries.

b. Vehicle Maintenance: Vehicles were deadlined for maintenance for a total of 101 hours.

12. Remarks: The support rendered by the personnel of Lowry AFB was exceptionally good in every respect.

13. Participating Personnel: The following personnel, detachments indicated, participated in this project:

Major William Stouppe	-	Detachment 3
Capt Durward G. Price	-	Detachment 7
SMSgt Joseph L. Wyatt	-	Detachment 3
MSgt Daniel G. Bertron	-	Detachment 2

TSgt	Michael R. Armour	-	Detachment 1
TSgt	Raymond Crandall	-	Detachment 3
TSgt	David R. Evans	-	Field Ops
TSgt	Billie L. Owens	-	Field Ops
TSgt	Marvin L. Seaman	-	Detachment 2
SSgt	Joseph Aranda	-	Detachment 3
SSgt	Stuart K. Carr, Jr.	-	Field Ops
SSgt	Richard C. Doerr	-	Detachment 2
SSgt	Johnnie B. Goodwin	-	Detachment 2
SSgt	Melvin Pilson	-	Detachment 2
SSgt	Kenneth D. Stehlik	-	Detachment 3
A1C	James E. Farris	-	Detachment 3
A1C	Henry L. Griffitts	-	Detachment 3
A1C	George E. Isaacs	-	Field Ops
A1C	Jerome E. Mulvihill	-	Detachment 3
A1C	David A. Parks	-	Detachment 3

*Durward G. Price*

DURWARD G. PRICE  
Captain, USAF  
Clearance Officer